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HISTORY OF SCIENCE.—*Joseph Henry builds an institution.*[1] PAUL H. OEHSER, Smithsonian Institution. (Communicated by JOHN E. GRAF.)

The year 1846 has been called "the year of decision," and indeed it is surprising to see how many important events in the history of our country revolve around that date. It was an exciting period. Things were happening at an appalling rate—appalling at least to a fledgling republic just barely three score and ten years of age.

Most important perhaps was the fact that as a nation we were suffering growth pains, and they were causing us a lot of grief. We were expanding toward the Pacific, treading on the toes of other territorial claimants. In 1846, after several years of heated contest, our argument with Great Britain over the Oregon boundary was settled by treaty, adding to our territory what is now Washington, Oregon, Idaho, Montana, and Wyoming. On our southern border we engaged in another squabble, and in 1846 a 2-year war with with Mexico broke out, from which we gained the area now included in California, Arizona, Utah, and New Mexico. In Congress the Wilmot Proviso was being argued and was causing agitation throughout the country with the possibility that "neither slavery nor involuntary servitude should ever exist in any part of territory acquired from Mexico." John C. Frémont had completed his explorations and conquests beyond the Mississippi, and the year before (1845) the Senate had published his reports full of descriptions of the new country and its possibilities. One of his thousands of readers, we are told, was Brigham Young, who thereby was inspired to lead his zealous band of Mormons westward in 1847 into the "Promised Land," the Great Salt Lake country.

The boundaries of knowledge, too, were expanding. In 1846 William T. G. Morton, a Boston dentist, demonstrated the successful use of anesthesia in surgery, of which the British medical journal *Lancet* said, "Next to the discovery of Franklin, it is the second and greatest contribution of the New World to science." Two years earlier, Samuel F. B. Morse, applying the electromagnetic discoveries of Faraday and Henry, demonstrated the practicability of the telegraph, which was soon to revolutionize commercial communication. Only a few years later both anesthesia and telegraphy were to prove their humanitarian usefulness in the tragic War between the States. The year 1846, too, was the time of two other important American inventions: the sewing machine of Elias Howe and the rotary printing press of Richard Marsh Hoe.

These were remarkably spectacular discoveries, changing the trend of men's lives and occupations, setting their eyes toward new horizons There were also other important but less sensational scientific events taking place. John James Audubon, the indefatigable ornithologist and artist, had just completed and seen through the press his last great work, "The Viviparous Quadrupeds of North America," in collaboration with his friend the Rev. John Bachman. In Boston there arrived from Switzerland in 1846 the learned Louis Agassiz, who became America's most popular scientist and most memorable teacher

[1] This article, here published in commemoration of the 150th anniversary of the birth of Joseph Henry, will form a chapter in the author's book on the history of the Smithsonian Institution to be published by Henry Schuman, Inc., New York, in the Life of Science Library. Received August 20, 1947.

and who wielded an influence in the natural sciences that was not to pass for several generations. Exploration was receiving great impetus. The United States Exploring Expedition, under the command of Capt. Charles Wilkes, had returned in 1842 after four years in the South Seas and Antarctic regions with great things to tell. It had brought back large collections of zoological and geological specimens from many parts of the world, and these were to furnish scientific stimuli for many years. The expeditions of John C. Frémont, already mentioned, to the Rocky Mountains and beyond, were also fruitful. The intrepid Frémont, with a handful of picked men, explored the South Pass to California, and defined the geography, botany, geology, astronomy, and meteorology of that region.

Such were the men and events that set the stage for Joseph Henry, the first Secretary and "architect" of the Smithsonian Institution.

"Joseph Henry," wrote the astronomer Simon Newcomb, "was the first American after Franklin to reach high eminence as an original investigator in physical science." Though only 49 years old when chosen to head the Smithsonian, he had already made his reputation as a physicist through his great discoveries in electromagnetism, and at that time he was perhaps America's most distinguished scientist. This choice proved to be an incredibly wise one, when it is considered how frequently unwise appointments of public officials are made. The Smithsonian Board of Regents, however, had set their mark high. They wanted, they resolved, a man possessing weight of character as well as a high grade of talent. He must possess "eminent scientific and general requirements." He must be capable of "advancing science and promoting letters by original research and effort, well qualified to act as a respected channel of communication between the Institution and scientific and literary individuals and societies in this and foreign countries." Furthermore, he must have efficiency as an executive officer and a knowledge of the world. Henry was their man.

When the call came for him to take over the direction of the newborn institution, Henry was serving as professor of natural philosophy in the College of New Jersey (now Princeton University). He had been at Princeton since the fall of 1832, and here he was happily situated, since he was able to carry on his researches which he had begun while associated with the Albany Academy. Furthermore, he enjoyed teaching, was well liked at Princeton, and had little reason for desiring a change.

Descended from Scotch Puritans who had settled in eastern New York State about the time of the American Revolution, Joseph Henry grew up around Albany, N. Y., where he was born on December 17, 1797. That same year Franz Schubert was born in Vienna and Heinrich Heine in Düsseldorf. Although Henry was to become so eminent a scientist, his first leanings were not toward science at all, but toward literature.[2] Early in life he developed a fondness for the theatre and might well have become a distinguished actor. As a youngster he seemed not particularly studious, and for a

[2] Mary A. Henry, in her unpublished Diary [in the Smithsonian Archives] covering the years 1858 to 1868, recounts an amusing anecdote of her father that shows him to have been a boy possessing normal juvenile ambitions but with perhaps an unusual degree of inventiveness. On May 26, 1865, Miss Henry wrote: "At night Father gave us a little incident of his boyhood which interested us. He said that a certain man in the village where he lived with his grandmother—it was a shoemaker I believe—annoyed him greatly by passing his hand roughly over his face, bending up his nose in the process and causing him considerable pain. He was a slight, delicate boy but determined to discover some means of self-defence. He at length hit upon the following expedient—his first experiment as he says in practical mechanics. At the approach of his tormentor he threw himself upon the ground and as the man stooped over him to seize him he caught hold of [his] ankles and placing his feet in his stomach with one dexterous kick sent him over backwards. He tried the same experiment several times upon some young men who were in the habit of teasing him, and greatly to the amusement and admiration of the bystanders. He mentioned during the conversation that his first ambition was to be a chimney sweeper. He had watched a certain individual somewhat his senior ascend his grandmother's chimney and was inspired with the greatest admiration for the calling. There was a small space between his grandmother's house and that of the next neighbor and his clothes suffered greatly in consequence of his efforts to [crawl] between the two walls chimney-sweep fashion."

while was apprenticed to a watchmaker to supplement the family's meager income. When he was about 16, however, his attention was accidentally directed to a book containing "Lectures on Experimental Philosophy, Astronomy, and Chemistry, Intended Chiefly for the Use of Young People," by an English clergyman, the Rev. George Gregory. His interest was so seriously and strongly aroused that he determined to make the pursuit of these matters of "natural philosophy" the great object of his life. He began to study, first at a night school and then at the Albany Academy, earning his way by teaching a country school and later tutoring to the family of Gen. Stephen Van Rensselaer, of patroon fame. Next he participated in a road-surveying expedition across the central part of New York from West Point to Lake Erie, gaining some valuable experience and fortifying his somewhat precarious health. When he returned he was engaged as a teacher at Albany Academy, and in 1828, at the age of 31, he was appointed professor of mathematics. In May 1830 he was married to his cousin Harriet L. Alexander, of Schenectady. Two years later he was called to Princeton.

The next ten years were fruitful ones—both for Joseph Henry and for American science. In addition to his courses and lectures in physics and mathematics, chemistry, mineralogy, and geology, he was able to conduct his own experiments that were to prove epochal. Let us summarize briefly Henry's scientific researches up to the time that he went to Washington. Conveniently, such a summary is provided by Henry himself in a letter dated December 4, 1876, and addressed to the Rev. S. B. Dod. He divides his account into 16 parts, which are here somewhat condensed but given essentially in Henry's own phrasing:

1. Previous to leaving Albany, he says, he made a series of experiments on electromagnetism in which he developed the principles of the electromagnet and applied the magnetic power produced in the invention of the first electromagnetic machine; that is, a mechanical contrivance by which electromagnetism was applied as a motive power. Also, while in Albany, he applied the results of his experiments to the first electromagnetic telegraph, in which signals were transmitted by exciting an electromagnet at a distance, whereby bells were struck in succession.

At Princeton he continued his experiments and constructed a still more powerful electromagnet—one that would lift over 3,000 pounds—and with it illustrated to his students how, by means of a relay-magnet, a large amount of such power might be called into operation at a distance of many miles.

Just before leaving on a trip to England in 1837 he again turned his attention to the telegraph. The first actual line of telegraph using the earth as a conductor, he says, was made in the beginning of 1836. A wire was stretched across the front campus of the college grounds, from the upper story of the library to the hall opposite, the ends terminating in two wells. Through this wire signals were sent from his house to his laboratory. [Here Henry interpolates a short account of the history of the invention of the telegraph, claiming that the electromagnetic telegraph was first invented by him in Albany in 1830, two years, he says, before Morse conceived the idea and seven years before he attempted to carry his idea into practice, and stating that the reason he did not take out a patent on his invention, as he was urged to do, was that he did not consider it compatible with the dignity of science to confine the benefits that might be derived from it to the exclusive use of any individual. He reiterates that he was the first to bring the electromagnet into the condition necessary to its use in telegraphy and to point out its application to the telegraph. He gives Morse great credit, however, for his alphabet and for his perseverance in bringing the telegraph into practical use. The fact remains, however, that Morse was issued a patent for the invention of the telegraph on June 20, 1840. Just how much credit is due Joseph Henry will perhaps never be fully settled.]

2. His next experiment concerned what he called "electrodynamic induction." In 1831 Michael Faraday had discovered that when a current of electricity was passed

through a wire from a battery, a current in an opposite direction was induced in a wire arranged parallel to this conductor. Henry discovered that induction of a similar kind took place in the primary conducting wire itself, so that although a current in passing through a short wire conductor would produce no sparks or shocks, if the wire were long enough both of these effects would be produced. By using as a conductor a flat ribbon, covered with silk, rolled into a spiral form, he found that brilliant sparks and other electrical effects of high intensity could be produced from a battery of low intensity.

3. Afterward he made a series of investigations that resulted in producing inductive currents of different orders, of different directions, and made up of waves alternately in opposite directions. He found also that a metal plate of any kind, placed between two conductors, neutralized this induction, and that this effect was due to a current in the plate itself. He found that a current of quantity was capable of producing a current of intensity, and vice versa.

4. He also demonstrated that electrodynamic induction with ordinary electricity could be produced at a remarkable distance. If a current were sent through a wire on the outside of a building, electrical effects were produced in a parallel wire inside the building. He found also that the induced current appeared to change its direction with the distance of the two wires and that the discharge of electricity from a Leyden jar is of an oscillatory character.

5. His next experiments related to "atmospheric induction," reminiscent of Benjamin Franklin's experiment in drawing lightning from the clouds. In this he used two large kites, the lower end of the string of one being attached to the upper surface of the other, the end of the whole being coiled around an insulated drum, the "string" consisting of fine wire. When the sky was perfectly clear the kites were flown, and sparks were drawn, said Henry, of "surprising intensity and pungency, the electricity being supplied from the air, and the intensity being attributed to the induction of the long wire on itself."

6. A related experiment was made on induction from thunder clouds. Using his tin roof as an induction plate, he soldered a wire to the edge of the roof, passed it into his study and out again through holes in the window sash, and fastened the other end to a metal plate in a deep well in front of his house. By breaking the circuit of that part of the wire in the study and inserting in the opening a magnetized spiral, needles placed in this were magnetized by a flash of lightning so far away that the thunder could scarcely be heard. He found also that the electrical disturbance thus produced was oscillatory in character—the discharge first passing through the wire from the roof to the well, then another in the opposite direction, and so on until equilibrium was restored.

7. This experiment led to a series of experiments with lightning rods which contributed greatly to our understanding of the nature of electricity. It was shown, among other phenomena, that when a powerful electrical charge such as lightning is transmitted through a portion of air, the air along the path of the discharge is "endowed for a moment with an intense repulsive energy. . . . It is to this repulsive energy, or tendency in air to expand at right angles to the path of a stroke of lightning, that the mechanical effects which accompany the latter are generally to be attributed."

8. Another series of Henry's investigations pertained to "the phosphorogenic emanation from the sun," in which he extended the list of known substances "which possess the capability of exhibiting phosphorescence" when exposed to electric discharge.

9. A new method of determining the velocity of projectiles was the subject of his next inquiry. The principle involved in this was "the instantaneous transmission of electrical action to determine the time of the passage of a ball between two screens, placed at a short distance from each other in the path of the projectile. . . . The observer is provided with a revolving cylinder moving by clock-work at a uniform rate, and of which the convex surface is divided into equal parts indicating a fractional part of a second. The passage of the ball through the screen breaks a galvanic circuit, the

JOSEPH HENRY (1797–1878), first Secretary of the Smithsonian Institution.

time of which is indicated on the revolving cylinder by the terminal spark produced in a wire surrounding a bundle of iron wires."

10. In collaboration with his brother-in-law, Stephen Alexander, Princeton professor of astronomy, Henry experimented to determine the relative heat of different parts of the sun's disk. It was shown that the sunspots radiated less heat than the adjacent parts and that all parts of the sun's surface did not radiate an equal amount of heat.

11. Another experiment was made with what was called a thermal telescope, which consisted of a long hollow cone of pasteboard, lined with silver leaf and painted outside with lampblack. The angle at the cone's apex was such as to cause all the parallel rays from a distant object entering the larger end to be reflected onto the end of a thermopile, which was connected with a galvanometer. When the axis of the conical reflector was directed toward a distant object of greater or less temperature than the surrounding bodies, such as a horse, the difference was immediately indicated by the needle of the galvanometer. When the instrument was directed toward the sky, to different clouds, and to the moon, various conclusions as to radiant heat could be drawn.

12. Further studies of radiant heat were made "to examine the nature of the fact mentioned by Count Rumford that balls of clay introduced into a fire under some conditions increase the heat given off into an apartment." He concluded that the "increase in the radiant heat, which would facilitate the roasting of an article before the fire, would be at the expense of the boiling of a liquid in a vessel suspended directly over the point of combustion."

13. In another investigation, pertaining to the diffusion of metals, he demonstrated that mercury could be siphoned up through a 3-foot piece of thick lead wire and proved that solid silver would dissolve in solid copper.

14. He investigated the constitution of matter with reference to its "liquidity" and "solidity," concluding that "rigidity differs from liquidity more in a polarity which prevents slipping of the molecules than in a difference of the attractive force with which the molecules are held together." Heating a liquid, he said, does not neutralize the attraction of the molecules but rather neutralizes the polarity of the molecules so as to give them "perfect freedom of motion around any imaginable axis." He explained that the reason that the tenacity or cohesion of pure water is greater than that of soap and water is that the mingling of the soap and water interferes with the perfect mobility of the molecules and diminishes the attraction.

15. He further investigated the cohesion of liquids, measuring the tenacity of soap-water films by placing on them pellets of cotton until they burst. It was concluded that the attractive force of the molecules of water for those of water (several hundred pounds per square inch) is approximately equal to that of the molecules of ice for those of ice. He explained why oil spreads over water by the fact that "the attraction of water for water is greater than that of oil for oil, while the attraction of the molecules of oil for each other is less than the attraction of the same molecules for water." These experiments in molecular physics were pioneering.

16. Finally, in his letter to the Reverend Mr. Dod, Henry described at some length his contribution to science in "the origin of mechanical power and the nature of the vital force." He defined and classified mechanical power as opposed to "vitality." Mechanical power, he said, is that which is capable of overcoming resistance, or that which is employed to do work; vitality is that mysterious principle which determines the form and arranges the atoms of organized matter. This "doctrine," as he termed it, was first presented in December 1844 to the American Philosophical Society.

This, then, was the stature of the man who came down from Princeton to head the Smithsonian Institution, a man at the very peak of a brilliant scientific career, with many fundamental discoveries to his credit. And we must always admire Henry for the high regard in which he held pure scientific research. To expand the boundaries of knowledge he believed to be his special forte, and he left to perhaps less imaginative and more enterprising men the task of

applying this new knowledge to the uses of mankind. He did not even take out patents on his discoveries that might have made him a fortune, and in some instances he failed to publish his studies promptly, with the result that he can not be given full credit for some of them; for example, honors for the discovery of electromagnetic induction he must share with Faraday.[3] His natural modesty in claiming priority deterred him. He was more interested in having the approval of his scientific equals than in the applause of the multitude. He saw clearly the value of abstract science and was eloquent in its defense. "He who loves truth for its own sake," he wrote, "feels that its highest claims are lowered and its moral influence marred by being continually summoned to the bar of immediate and palpable utility."

One of the first jobs confronting the new Smithsonian Secretary was to supervise the construction of a suitable building to be the home of the Institution. Congress already, in the Act of Establishment, had placed on the Board of Regents the responsibility for the choice of a site[4] and the erection of the building. It should be constructed of "plain and durable materials and structure, without unnecessary ornament, and of sufficient size, and with suitable rooms or halls for the reception and arrangement, upon a liberal scale, of objects of natural history, including a geological and mineralogical cabinet; also, a chemical laboratory, a library, a gallery of art, and the necessary lecture rooms."

There was little delay in getting the building under way, and the cornerstone was laid on the first day of May 1847, with impressive ceremonies attended by a large procession that included President Polk and his Cabinet. Accounts of the occasion tell us that the same gavel was used as that employed by George Washington when he laid the first cornerstone of the United States Capitol. They do not tell us, however, exactly which stone is the cornerstone except to infer that it is on the south side of the building. Either by weathering off of the inscription or by subsequent landscaping and filling in around the building, this architectural detail has been lost to us. An address fitting to the occasion was made by the Chancellor of the Institution, Vice President George M. Dallas, in which he described the building to be. "Its exterior," he said, "will present a specimen of the style of architecture that prevailed some seven centuries ago, chiefly in Germany, Normandy, and southern Europe, which preceded the Gothic, and continues to recommend itself, for structures like this, to the most enlightened judgment. It is known as the Norman, or, more strictly speaking, the Lombard style. It harmonizes alike with the extent, the grave uses, and the massive strength of the edifice; it exacts a certain variety in the form of its parts; and it authorizes any additions that convenience may require, no matter how seemingly irregular they may be."

The building was the first of this Romanesque twelfth-century style ever to be erected in this country for non-ecclesiastical uses. The architect was James Renwick, Jr., of New York, who also designed Grace Church and St. Patrick's Cathedral in New York City. The stone for the building, a lilac-gray freestone, was quarried from the banks of the Chesapeake and Ohio Canal, near Seneca Creek, Maryland, and only 23

[3] Credit for the discovery of the electrical principle of self-induction is now generally conceded as belonging to Henry, and this was officially recognized by the International Congress of Electricians in 1893, when the name *henry* was given to the standard of inductive resistance.

[4] President Polk himself helped the Regents in the selection of the site, but the final decision apparently followed the recommendation of Regent William W. Seaton, mayor of Washington. Polk wrote in his diary: "At nine o'clock this morning [Wednesday, Sept. 9, 1846] . . . I rode out in my carriage to meet the regents of the Smithsonian Institute [sic] on the public grounds lying west of the Capitol and south of the President's House, with a view to locate the site of that institution. I met the regents on the ground, and spent nearly an hour with them on foot in examining the grounds. Opinions were freely expressed. The most elevated ground, and, as I think, the most eligible site, lies between 12th and 14th Streets containing about 32 acres. . . . Most of the regents expressed a preference for this location. Mr. W. W. Seaton . . . earnestly urged that the location should be made west [obviously he meant to say east] of 12th street and between that street and the Capitol. This is a lower situation than that west of it, and in no sense, as it strikes me, so eligible." The actual location—"upon the center of Tenth Street"—was determined on March 20, 1847, by a resolution of the building committee.

miles from the site. The length of the building from east to west measures 447 feet, and its greatest width is 160 feet. The building has nine towers of various shapes and ranging from 60 to 145 feet in height.

By April 1849, the east wing of the building was completed to the point where it could be occupied by the Secretary and his staff. Before the end of the year the west wing was finished. The entire building, interior and exterior, was not completed immediately, however, and some construction was still going on in 1857, although the main edifice seems to have been finished in December 1854.

On January 24, 1865, in spite of the fact that precautions had been taken to make the Smithsonian Building fireproof, a fire broke out in the main portion, destroying the roof, the interior of the upper story, and the interior of the two large north towers and the large south tower. Although the losses were not considered to be severe, many records, publications, and manuscripts were destroyed, as well as apparatus and a large stock of tools and instruments. Perhaps the most serious loss was the collection of the personal effects of James Smithson, including numerous manuscripts written by him. Another unfortunate loss was a valuable series of Indian portraits and scenes (in all about 150 canvases) which had been temporarily deposited by the artist, J. M. Stanley, in 1852; all but seven of these pictures were destroyed. The building was repaired at a cost of about $150,000.[5]

By the time of the fire, the Institution had been in operation nearly 20 years. During this period Professor Henry had successfully put into effect a plan of organization which was thereafter to guide its course.

Even before he left Princeton, Henry was requested by the Board of Regents to study the will of James Smithson and present a plan of organization, so that when he arrived in Washington he had already given considerable thought to the problem of what the proper functions of the Institution should be. He laid down a few basic principles on which he thought the organization should operate. One was that the Institution should undertake nothing that could be done adequately by other agencies of the country. Another was that the Smithson bequest was intended for the benefit of mankind, and that, therefore, "all unnecessary expenditure on local objects would be a perversion of the trust." The United States Government would act as trustee to carry out the will of Smithson. The Institution, however, would not be a national establishment in the usual sense, but rather the establishment of an individual, to bear and perpetuate his name. The objectives of the Institution were clear—first, to increase, and second, to diffuse, knowledge among men. Inasmuch as the will did not define or restrict in any way the particular kind of knowledge to be diffused and augmented, no branch of knowledge could rightly be excluded from its share of attention. Said Henry, "Smithson was well aware that knowledge should not be viewed as existing in isolated parts, but as a whole, each portion of which throws light on all the other, and that the tendency of all is to improve the human mind, and to give it new sources of power and enjoyment."

With these liberal principles in mind, Henry proposed that the Institution, in order to *increase knowledge*, should (1) stimulate men of talent to make original researches, by offering suitable rewards for memoirs containing new truths, these memoirs to be published in a series of quarto volumes called "Smithsonian Contributions to Knowledge"; and (2) appropriate annually a portion of the income for particular researches, under the direction of suitable persons. To *diffuse knowledge* he proposed (1) to publish a series of periodical

[5] One account of the fire says: "A series of cases intended for ethnological specimens had been constructed in the gallery on the second floor, which made it necessary to rearrange the Indian paintings. The day was extremely cold, and with a view to their comfort in hanging the pictures the workmen brought a stove into the room and inadequately inserted the pipe in a ventilating flue which opened under the roof. The conflagration which ensued burnt out the entire upper story of the main building, as well as the central main towers on both the north and south sides. . . . The contents of the upper gallery were almost entirely destroyed. These . . . consisted mainly of the Indian paintings of J. M. Stanley, Charles B. King and others, probably other paintings, and the marble copy of the Dying Gladiator."

reports on the progress of the different branches of knowledge; and (2) to publish occasionally separate treatises on subjects of general interest. At the meeting of the Board of Regents on December 8, 1847, Henry presented the details of this general plan for the Board's consideration and approval. Furthermore, the plan was submitted to a number of literary and scientific societies, and it must have been gratifying to the new Secretary to have his work widely approved. "In every case," he reported, the program "received their unqualified approbation."

On December 13 the plan was officially adopted. The stage was now set. The work of, as well as an edifice for, the Smithsonian Institution could now start.

As a matter of fact, it had already started. In May 1847, Professor Henry had received a letter from two archeologists of Chillicothe, Ohio—E. George Squier, A.M., and E. H. Davis, M.D.—who had been investigating the ancient Mound Builders of the Mississippi Valley region. They had prepared an elaborate manuscript based on a study of over 200 of the Indian mounds, comprising, they said, the results of extensive original surveys and explorations, and they wished to submit it for publication by the Smithsonian Institution. This, it appeared, promised to be what Henry was looking for to start the new series "Smithsonian Contributions to Knowledge." He received the manuscript and, after submitting it for critical examination to several competent scholars, accepted it for publication. It was published on December 1, 1848, under the title "Ancient Monuments of the Mississippi Valley," illustrated by 48 lithograph plates and 207 wood engravings. Uncopyrighted, a copy was sent to every principal library of the world, though the edition was small. It was the first scientific publication to be issued by the Institution.

It should be remembered that in 1848 there were very few outlets for the publication of such monographs as that by Squier and Davis. The American Philosophical Society at Philadelphia and the American Academy of Arts and Sciences at Boston issued publications, and there was an increasing number of scientific journals springing up, many of them organs of scientific societies. But for the most part authors had to pay for the publication of their work, especially if it was anything as pretentious and costly as "Ancient Monuments of the Mississippi Valley." Learned societies then did not have much money to spend on quarto volumes and expensive illustrations. It can be readily appreciated what this new Smithsonian publication plan meant to the scientists of America. They now had a new and dignified medium for the publication of their researches and could be assured of world-wide distribution of their papers. Henry knew, though he had himself been dilatory in the prompt publication of some of his own electromagnetic discoveries, that science is valueless unless given to the world to be put to whatever use the human race desires or is capable of. Said Henry, "The real workingmen in the line of original research hail this part of the plan as a new era in the history of American science."

The Contributions soon became widely known among scholars, and in the ensuing years many important monographs appeared in the series. The only requirement was that each paper should constitute a positive addition to knowledge based on original research. The series ran for 68 years, being discontinued in 1916. A few of the well-known papers in this series are: "Memoir on Mechanical Flight," by Langley and Manly; Coffin's "The Winds of the Globe"; Shaler's "Comparison of Earth and Moon"; Morely's "On the Densities of Oxygen and Hydrogen, and the Ratio of Their Atomic Weights" and Morgan's "Systems of Consanguinity and Affinity of the Human Family."

The original act of Congress establishing the Smithsonian made specific provision for a library, and it was therefore incumbent upon the new Secretary to begin its formation at once. On January 26, 1847, Charles Coffin Jewett, a young professor of modern languages and literature at Brown University, was appointed Assistant Secretary of the Institution to serve as librarian. The initial purpose of the library was to procure "a complete collection of the memoirs and

transactions of learned societies throughout the world and an entire series of the most important scientific and literary periodicals," and it was agreed that a special library of this kind could be a means both of increasing and diffusing knowledge. Professor Jewett was an energetic man with ideas and was far in advance of his time in library planning and technique. He became recognized as one of the most active librarians and bibliographers of his day, and under his direction the Smithsonian collection grew, in six years, to 32,000 volumes. It was fast becoming, under his tutelage, a national reference and bibliographic center. One of Jewett's original ideas was a plan whereby, instead of the expensive printing of catalogues of American libraries, separate stereotyped titles would be made available to librarians. In this way a general catalogue of the public libraries of the United States could be constructed. This was a genuine contribution to library science and was later developed by the Library of Congress.

Jewett performed fine work in laying the foundation for the Smithsonian Library. If anything, however, he was overambitious in plans for the future in view of the Institution's limited funds, which had to be spread over an increasing variety of activities. Jewett felt that he should spend on the library all that the law allowed. In 1855 a difference of opinion arose between Henry and Jewett over the library administration and authority, chiefly over the matter of expenditures and as to whether the library should be developed along predominantly scientific or literary lines. Science and Henry prevailed, and Professor Jewett was retired from office after eight years' service. Thereafter he became Superintendent of the Boston Public Library and there rendered notable service for a number of years.

This library question, to be sure, was an animated one; and Jewett's release started a Congressional investigation and caused the resignation of the Hon. Rufus Choate from the Board of Regents. In general, however, Secretary Henry's policy was upheld, namely, that the library should not be developed at the expense of the other activities of the organization. The indorsement of the Secretary's policy by Congress definitely cleared up the question as to whether the creation of a great library should be one of the Institution's main objects. Henry felt strongly that the Smithsonian should not engage in any way in competition with other organizations and that although a modest library of scientific literature was needed for the use of its own staff, it was not the function of the Smithsonian to build up a large national library in competition with the Library of Congress and other institutions. Rather, let the Smithsonian Library work in cooperation with other libraries, but avoid needless duplication of functions and materials.

An example of this duplication was the matter of copyright. For nearly 13 years after the founding of the Institution, it was required by law that anyone wishing to secure copyright of a book must deposit one copy with the librarian of the Smithsonian Institution and another copy with the librarian of Congress. This dual requirement, it seemed to Henry, was unnecessary and promised to be a burdensome one; and in 1857 he succeeded in having section 10 of the original Smithsonian Act of 1846 repealed, and the Library of Congress became the sole copyright depository.

A few years later, in 1866, another "merger" was effected, when the Smithsonian Library by Congressional authority turned over to the Library of Congress about 40,000 volumes of scientific works, to form the basis of what has since been known as the "Smithsonian Deposit." "The object of this transfer," wrote Henry, "is not, of course, to separate this unique and highly prized collection of books from its relations to the Smithsonian Institution, for it must still bear its name and be subject to its control, but merely to deposit it where its preservation will be more certain [thinking probably of the fire in the Smithsonian Building] and its usefulness more extended." In the eighty-odd years that have passed since the original "Smithsonian Deposit," almost a million volumes and parts have been added to it, to make it one of the largest collections of scientific literature in the world. It is especially com-

plete in the transactions and proceedings of scientific societies.

The removal of these books not only relieved the space problem in the Smithsonian Building but also eased the financial strain by putting upon the shoulders of Congress the responsibility for the upkeep of this collection. Furthermore, it was in harmony with Joseph Henry's general policy of trying to keep the organization of the Institution from becoming too cumbersome and from outgrowing its income. Besides a library, the Smithsonian Act had directed that a museum, an art gallery, and courses of lectures should be under the aegis of the Smithsonian. Henry, however, though not openly opposed to these, believed that they should be projects only temporarily undertaken by the Institution, to be turned over to other agencies when possible. In this way, he felt, the Smithsonian could concentrate its activities on matters of benefit to all mankind rather than on those of local and restricted interest.

So far as the museum was concerned, however, this was destined to remain under the direction of the Smithsonian and to grow into a large and important organization supported by Government funds. Like the library, the museum flourished inordinately, until in 1866 it was stated that the collections, "taken as a whole, constitute the largest and best series of the minerals, fossils, rocks, animals, and plants of the entire continent of North America, in the world." Of the large North American and European mammals it had the best collection in the United States; of birds, its collection ranked second only to that of the Academy of Natural Sciences of Philadelphia; and of fishes only Louis Agassiz had a larger collection. So, even though Secretary Henry would like to have seen the museum subordinated or even divorced from the Institution, Congress ruled otherwise, and the museum continued to develop and occupied generous quarters in the new building. On July 5, 1850, Spencer Fullerton Baird, biologist, was made Assistant Secretary of the Institution to take charge of the museum and to aid in the publication program. Baird as Assistant Secretary, and later as Secretary, was destined to play a signal role in the development of the museum and in the affairs of the Institution.

Another principle laid down by Joseph Henry that guided the Smithsonian's course of action from the very beginning was cooperation. He early realized that if the Institution was to fulfill its high purposes it must extend its activities and influence beyond that directly covered by its limited income. To do this meant to fit into the scientific life of America in the give-and-take spirit. It was well enough to spend large sums in aid of research and in publishing and distributing Contributions to Knowledge by scientific investigators who had no other channel by which to make known the results of their researches, but it was necessary also for other institutions and individuals in turn to contribute to the work of the Smithsonian. Something of this kind was absolutely necessary, for the Smithsonian simply did not have the funds or the staff to carry on all the activities it was called upon to perform. In return, it would lend its prestige, publish results, and correlate.

In his second annual report (for the year 1848) Henry outlined a project that was to furnish a notable example of this cooperation. It was an experiment in the science of meteorology. His plan was to obtain weather reports from a great network of voluntary observers scattered over the country. He was especially interested in assembling long-range data on climate and weather from stations in every region, and in this way furnishing a sound foundation upon which the science of meteorology could build. We know today how far this science has advanced, how much we depend on weather forecasts and the daily weather report. We remember what an important part meteorology played in World War II. But in Henry's day it was new; Henry was a pioneer, and he and the Smithsonian must have credit for initiating the work that finally culminated in the United States Weather Bureau.

After persuading the Regents of the Institution to support his project, he went ahead. There would be, he said, three classes of observers: "One class, without

instruments, to observe the face of the sky as to its clearness, the extent of cloud, the direction and force of wind, the beginning and end of rain, snow, etc. A second class, furnished with thermometers, who besides making the observations above mentioned, will record variations of temperature. The third class, furnished with full sets of instruments, to observe all the elements at present deemed important in the science of meteorology."

This proved to be a cooperative enterprise of the highest degree. First there were the individual voluntary observers distributed over the entire continent, and by 1852 these numbered about 200, reporting directly to the Smithsonian. Then the States of New York and Massachusetts cooperated by setting up weather stations with instruments at various academies; these had State support but were directed by the Institution. Further observations were made at a hundred or so military posts of the United States, under the direction of the Surgeon General of the Army. Separate series of observations were made by exploring and surveying parties and reported back to the Institution. In Canada, or British America as it was then called, observations were made at the various posts of the Hudson's Bay Company. Stations reached to Nova Scotia, Panama, and Bermuda, and there was one observer at Ascención, Paraguay. The work had the active support of such eminent meteorologists as Arnold Guyot, James P. Espy, Elias Loomis, James H. Coffin, and William Ferrell. Professor Guyot, the Swiss scientist who had just come to the United States, was entrusted with the selecting and ordering of the improved instruments required and with the job of preparing a set of "Directions for Meteorological Observations" to serve as a guide for the observers.

Another paragraph in Henry's second annual report was epoch-making. "As a part of the system of meteorology," he said, "it is proposed to employ, as far as our funds permit, the magnetic telegraph in the investigation of atmospheric phenomena. By this means, not only notice of the approach of a storm may be given to distant observers, but also attention may be directed to particular phenomena, which can only be properly studied by the simultaneous observations of persons widely separated from each other. For example, the several phases presented by a thunderstorm, or by the aurora borealis, may be telegraphed to a distance, and the synchronous appearances compared and recorded in stations far removed from each other. Also, by the same means, a single observatory . . . may give notice to all persons along the telegraph lines, of the occurrence of interesting phenomena. . . ." Knowledge of an approaching storm, he thought, could be of great advantage to agriculture and commerce, and this, he concluded, "is a subject deserving the attention of the general government."

Henry, then, must be given credit for first utilizing the electric telegraph in this way, although it may have been suggested by others. As Cleveland Abbe wrote in 1871 in the *American Journal of Science*. "The Smithsonian Institution first in the world organized a comprehensive system of telegraphic meteorology." By 1857, there was a series of weather reports coming in via the National Telegraph line from New Orleans to New York and as far west as Cincinnati. The *Washington Evening Star* was the very first newspaper to publish them. Naturally they exited much interest and were soon extended farther north and westward. The next year a daily weather map, compiled from telegraphic reports received at 10 o'clock every morning, was exhibited in the Smithsonian Building.

All this combined in a practical way the telegraph and the work of the weather observers throughout the country. The fast-accumulating weather data were soon put, however, to strictly scientific uses. Voluminous reports, maps, tables, and charts were prepared and published on all phases of the work—rainfall, snowfall, temperatures, barometric pressure, storms, meteors, auroras, etc. Between 1852 and 1884 four editions of "A Collection of Meteorological Tables" (later expanded into the Smithsonian Meteorological Tables), compiled by professor Guyot, were issued; and there were many more important scientific fruits of the

work. Although the Civil War, and also the disastrous Smithsonian fire, interrupted the work in many ways, it did not end the cooperative spirit that the enterprise seemed to engender. In 1864 the North American Telegraphic Association, covering the entire United States and Canada, gave the free use of all its lines for the scientific objects of the Institution. In the meantime, however, there began agitation in favor of "a meteorological department under one comprehensive system with an adequate appropriation of funds." Henry, too, was in favor of such a plan, and in 1869 Congress passed a resolution establishing the Weather Bureau of the United States Signal Service. Consequently, the Smithsonian's great system of meteorological reports was turned over to the new bureau. Few new agencies of the Federal Government have ever had so generous a birthright and so solid a foundation. It represents perhaps the greatest experiment in cooperation that the Smithsonian ever attempted, but its unqualified success was an inspiration and pattern for many less pretentious undertakings.

Always uppermost in Joseph Henry's mind was the great purpose that James Smithson prescribed for his Institution—the "increase and diffusion of knowledge among men." This must outweigh all other considerations, and it became the Institution's motto.[6] "The worth and importance of the Institution," wrote Henry in 1852, "are not to be estimated by what it accumulates within the walls of its building, but by what it sends forth to the world."

Henry was referring here not only to the distribution of the Institution's own publications but also to another effective scheme of diffusing knowledge that had been inaugurated in 1849 designed to facilitate the distribution and exchange of literary and scientific publications between this and other countries. It was a happy idea, and today after a hundred years it is still one of the continuing functions of the Smithsonian, although the financial support of the Exchange Service has long since (1881) been shouldered by Congressional appropriations. Henry left much of the organization of the Exchange Service to Assistant Secretary Baird and put him in charge of it. This is how the plan originated:

With the appearance in 1848 of its first publication, "Ancient Monuments of the Mississippi Valley," the Institution was confronted with a problem of how best to distribute copies where they would be the most useful and accessible. In addition to the American distribution, a few hundred copies were sent to scientific and other learned institutions abroad, with the request that they exchange publications. At first the number of responses to the proposal was small, but by 1852 Professor Henry reported that 4,744 articles were received. To continue this desirable exchange of intelligence with other nations, Henry appointed agents in a number of foreign countries. Especially cooperative was the Royal Society of London. Gradually the system expanded until Henry was able to offer other learned societies of the United States the facilities set up at the Institution in distributing their publications abroad. The Exchange Service became a clearing house for the receipt and distribution of scientific literature. Incoming packages of exchange publications were admitted free of duty and were allowed to pass the customs without the delay of an examination. Many of the great transportation companies and steamship lines extended to the Exchange Service the privilege of free freight.

From the beginning the United States Government departments made use of the Exchange Service in obtaining official documents of other governments in exchange for their own. In 1867 Congress passed an act systematizing this governmental interchange, but it was not until 1881 that any Congressional financial support was given the system. By that time the Exchange Service was costing so much, in spite of generous free freight and other concessions, that something had to be done, and Congress assumed part of its support by appropriating $3,000. This support was con-

[6] The seal of the Smithsonian Institution adopted in 1847 carried a left-facing likeness of the founder, James Smithson. The new seal, designed by Augustus St. Gaudens and adopted in 1893, carries the words "For the increase and diffusion of knowledge among men—*per orbem*."

tinued and increased, until just before World War II the annual appropriation for the Service reached approximately $50,000.

For about 40 years the International Exchanges operated unofficially, so to speak, from the standpoint of international law. Beginning in 1875 international conferences were held in Paris and Brussels, which discussed the exchange between countries not only of governmental documents but also of scientific and literary publications, and in 1886 a formal agreement was reached. Eight nations ratified the convention—"International Exchange of Official Documents, Scientific and Literary Publications"—and it was officially proclaimed by the President of the United States on January 15, 1889. Other nations "came in" later, and with those countries that did not ratify special arrangements were made for exchanges. The Smithsonian Institution was recognized as the official exchange agency of the United States.

Briefly, this is how the Exchange System, inaugurated by Joseph Henry, works at the present time: Libraries, scientific societies, educational institutions, and individuals in this country who wish to distribute their publications abroad as gifts or exchanges send the separate addressed packages to the Smithsonian Instititution, carriage cost prepaid. There they are sorted by countries and forwarded with similar shipments from other organizations to the exchange agencies in other parts of the world, where they are distributed to the addressees. Similarly, shipments of publications from exchange agencies abroad to the Smithsonian are distributed free to addressees in the United States.

The Smithsonian International Exchange Service—originating, as we have seen, in Professor Henry's efforts to distribute Smithsonian publications most effectively—has now been in operation for a full century, with but two major interruptions, these occasioned by World Wars I and II. Even throughout the years of World War II exchanges were continued with all countries of the Western Hemisphere and with a few in other parts of the world. The Exchange Service has demonstrated itself as a very tangible expression of the Smithsonian Institution's part in "the diffusion of knowledge." It, again, is an instance of that cooperative kind of enterprise envisioned by Joseph Henry as the most effective means for the Smithsonian to fulfill its destiny.

There was still another means of "diffusing knowledge," especially among the residents of the National Capital, that was initiated as soon as the new Smithsonian Building became available. This was a series of free lectures. Professor Henry never was in full favor of these lectures for he felt that, being local, they were "too limited in their influence to meet a proper interpretation of the will of Smithson." However, they had been ordered by Congress, and Henry could not do otherwise than to provide them. He sought to maintain the lectures on a high plane, "to improve the public taste rather than to elicit popular applause." The lecturers, many of whom were invited from a distance, were paid for their services in accordance with the modest appropriations made for the purpose, but it is evident in noting some of their names that Professor Henry was able to obtain the best to be had.

It was—the mid-nineteenth century—the heyday of the popular lecture. Long before the days of the radio and motion-picture and other modern forms of mass entertainment, the average man seemed hungry for knowledge and willing to put forth effort to improve his education, and a series of a dozen lectures on geology, astronomy, history, or literature would be taken in stride. Every city of any size had its lecture courses (this was before the days of the Chautauqua when every village also had them), usually sponsored by the intellectual associations, such as the Lowell Institute of Boston, the Athenaeum of Richmond, and the Cooper Union of New York; and in many cases the lecturer's remuneration was liberal enough to attract men of reputation. The great Emerson traveled a lyceum circuit that took him as far west as St. Louis and Milwaukee. Dr. Oliver Wendell Holmes went as far as Cincinnati and Louisville. "Public lectures," wrote Henry in the report for 1852, "have become one of the characteristics of the day, and

next to the press tend, more than any other means of diffusing knowledge, to impress the public mind."

The Smithsonian lectures were given chiefly while Congress was in session. The first lectures under the auspices of the Institution were a series delivered, beginning on February 25, 1847, in Washington's Odd Fellows Hall, by William Scoresby, the English Arctic explorer, on "The Construction and Use of the Rosse Telescope." The next ones were a course of four on "Modern Athens" delivered by Professor Koeppen of Denmark in Carusi's Hall, beginning on April 6, 1849. A course of six on "Geology" followed, beginning on April 30, 1849, by Dr. Edward Hitchcock, president of Amherst College—the first to be given in the Smithsonian Building. As facilities improved the program was expanded; in 1850, during the last session of Congress, lecturers appeared and delivered one to several lectures apiece, ranging from a single lecture on "Holland," by the Rev. Dr. George W. Bethune, to a course on "The Unity of the Plan of the Animal Creation," by Prof. Louis Agassiz, of Cambridge, Mass. "Whatever may have been the effect of these lectures in the way of diffusing knowledge," commented Henry, "it is evident, from the character of the men by whom they were delivered, that they presented truths intended to elevate and improve the moral and intellectual condition of the hearers." In the roster of lecturers for the next few years we find such names as Dr. Benjamin Silliman, of Yale College; Prof. Benjamin Silliman, Jr.; Pres. Mark Hopkins, of Williams College; Dr. B. A. Gould, Jr., of Cambridge; Prof. Louis Agassiz, who in 1863 became a Regent of the Institution; Prof. Stephen Alexander, of the College of New Jersey; Prof. A. Guyot; and Hon. Henry Barnard, educational reformer. As the years went by, however, the lecture phase began to wane somewhat, no doubt aided by Henry's reservations as to the Smithsonian's proper interest in such lectures, valuable as they might be. Today, except for an occasional one, usually by a member of the staff, and the annual Arthur Lecture on some phase of solar research, the "Smithsonian lecture" is but a memory. In late years the lingering lecture needs of the general populace of the City of Washington seem to have been supplied chiefly by the National Geographic Society in its popular winter series. The lecture was an influential phase of American life that is largely past, and it is probable that modern educational and entertainment methods have permanently supplanted it. But it was good while it lasted, and the Smithsonian played an active and dignified part in the half century or so of its greatest popularity. The Lecture Room in the Smithsonian Building was entirely burned out by the fire of 1865, and it was never reconstructed as such.

Professor Henry's own researches during this period suffered by reason of his administrative duties, but by no means did his scientific work entirely cease, and his contributions to science at Washington were numerous. He was active in support of the American Association for the Advancement of Science, which in 1848 he had helped to organize. During the Civil War he was a trusted friend of President Lincoln and was called upon many times for advice in scientific matters. He assisted Lincoln in planning the National Academy of Sciences and was one of its original members. In 1864 he wrote, "A large share of my time has been devoted for the last four years to investigations required by the public exigencies." This part played by Henry and the Institution in the Civil War and the services he rendered to the various Executive Departments in scientific matters can never fully be told, however, as the official records and correspondence were lost in the fire. While serving on the U. S. Lighthouse Board, of which he was made chairman in 1871, Henry conducted a series of experiments that led to the substitution of lard oil for sperm oil for use in the extensive system of lighthouse beacons, before kerosene became an abundant fuel. This, it has been estimated, saved the Government as much as $100,000 a year. Based on his studies of the laws of sound, he also devised a siren fog-signaling system, which was later adopted by the Government.

In 1854 he conducted a series of experiments on the strength of different kinds of

building stones offered for the extension of the United States Capitol. He experimented in the field of acoustics. He constructed a large sulphuric-acid barometer, which was in successful use for many years, and had its readings constantly recorded. Other important experiments of Henry's might be mentioned to show the variety of his interests and abilities. Yet he was so scrupulous that he allowed none of his own researches to be published by the Institution. As one account puts it, "Many of his most valuable papers must be searched for in unsuggestive volumes of Agricultural or Light-House Board Reports."

Busy as he was with Smithsonian affairs, he somehow found time for all these activities. He was called upon to make many public addresses; and his position required that he keep in close contact with scientific men and work throughout the country. In 1868 he was chosen President of the National Academy of Sciences and held that position until his death. Meetings of the Academy were held in the Smithsonian Building. In 1871 he was active in organizing the Philosophical Society of Washington and served as its president as long as he lived. In 1870 the Board of Regents granted him a leave of absence (plus expenses) that he might take a trip to Europe "for the interests of the Institution in the promotion of science . . . and to consult with savants and societies of Great Britain and the continent." This trip proved to be a most profitable one, one of his accomplishments being to testify before an English Government Scientific Commission regarding the methods and aims of the Institution. After an absence of four and a half months he returned much improved in health and with impressions as to science and education in the Old World that were to prove of value to him in directing the affairs of the Institution.

Visitors to the Smithsonian today are sometimes told that in the early days some members of the staff resided in the Smithsonian Building. Professor Henry and his family lived in the east wing for 23 years—from 1855 until his death. The Henrys were a family of the old school, close-knit, loyal, and devoted to one another, deriving their greatest pleasure in each other's company. There were four children—the three daughters, Mary, Caroline, and Helen, and the son, William Alexander Henry, who died in 1862 in early manhood. Two others had died in infancy. The family's residence in the Smithsonian Building spanned the entire period of the Civil War. From here they watched the Confederate flag flying over Alexandria six miles away; saw the regiments passing through the city; followed the daily news of battles; looked upon the prisoners and the wounded being brought in; waited for news of peace; lived anxiously through the sad event of Lincoln's assassination; wondered, even with the Union saved, what was to happen to the nation. Through it all their home was a bright spot. It was more than a home. It was a center of intellectual life in Washington; and always welcome were visiting scientists, professors, writers, lecturers, officers, and other distinguished men who came to the city. Some of the cheerful fireplaces of the Henrys' living quarters are still in use in the east-wing executive offices in the Smithsonian Building—impressing one now as a rather refreshing anachronism among the modern Government office buildings on Washington's Mall.

Joseph Henry had been reared in the stern atmosphere of Scotch Presbyterianism. He was a practicing Christian and brought up his family accordingly. His science never destroyed his religious faith, nor did he ever see any basic conflict between science and religion. With Lincoln, the family attended the New York Avenue Presbyterian Church, and they were active in church affairs.

In December 1877 Henry was stricken with nephritis and died the following May 13, in his eighty-first year. In his death American science lost its most distinguished leader and the Smithsonian Institution its great "architect" and chief. He was buried in Oak Hill Cemetery in Georgetown, D. C. Tributes and eulogies were paid him by statesmen and scientists, memorial services were held in the United States Capitol, and a bronze statue was erected to his memory on the grounds of the Smithsonian.

John Quincy Adams said of the Smith-

sonian, "Of all the foundations or establishments for pious or charitable uses which ever signalized the spirit of the age or the comprehensive beneficence of the founder, none can be named more deserving the approbation of mankind." Joseph Henry, more than any other person, made that statement true, and that is his eternal monument. On May 17, 1878, four days after Henry's death, Assistant Secretary Spencer Fullerton Baird, of Carlisle, Pa., was elected the new Secretary.

BOTANY.—*A revision of* Chorisepalum, *an endemic genus of Venezuelan Gentianaceae.*[1] JOSEPH EWAN, U. S. Bureau of Plant Industry, Soils, and Agricultural Engineering.

First discovered on Mount Duida, Venezuela, in November 1928, and up to the year 1944 known only from the single original species, *Chorisepalum* is known today to be a genus of four remarkably distinct species living on the table mountains or *cerros* of Venezuela, including Roraima. The original species, *Chorisepalum ovatum* Gleason, was described from the unicate collection, *G. H. H. Tate* 462, as a straggling shrub 8 feet tall, with large green tubular flowers, growing at the "bottom of slope of Ridge 25" on the summit of Mount Duida, at 5,200 feet elevation. It has not been re-collected. No illustration accompanied the original publication of the monotypic genus and since no duplicates were available for distribution it remained a nearly forgotten genus. When, therefore, I received for naming an excellent series of Gentianaceae from Dr. Julian A. Steyermark, of the Chicago Natural History Museum, I was first quite puzzled by the three collections here described as three new species of *Chorisepalum*. I had indeed designated them as species of a probable new genus when I became aware that I had bypassed the publication of the new genus established in 1931 by Gleason and Wodehouse in the account of the Tyler-Duida Expedition although I had consulted that report repeatedly. Thereupon my suspicion that what I had earmarked as a new genus would prove to be *Chorisepalum* was borne out at once when I examined the type of *C. ovatum* kindly lent by the New York Botanical Garden. It seems appropriate, therefore, to bring together at this time all our present information on the genus, with illustrations, since the genus has not heretofore been illustrated in botanical literature.

It is real pleasure to take this opportunity to thank Dr. J. A. Steyermark for his kindness in entrusting this material to me for study, along with the entire series of his Ecuadorian and Venezuelan Gentianaceae. Seldom, indeed, have botanists been able to work with such well-prepared material in such quantity, accompanied by such full field notes as has been possible from Steyermark's most recent South American explorations. As one who has had an introduction to plant collecting in the American tropics, I can especially appreciate his accomplishments and I congratulate him.

In the citation of specimens the following abbreviations are employed: *F*, Chicago Natural History Museum, Chicago, Ill.; *US*, U.S. National Herbarium, Washington, D. C.; and *USNA*, U. S. National Arboretum Herbarium, Bureau of Plant Industry Station, Beltsville, Md.

GENERIC RELATIONSHIPS

At the time Gleason and Wodehouse described the genus *Chorisepalum* they suggested its affinities with *Zygostigma* in its separate sepals, and with *Rusbyanthus*, in the completely 2-celled ovary, believing the latter to be its nearest relative. In my opinion *Chorisepalum* is most closely related through *C. psychotrioides* and *C. rotundifolium* to *Macrocarpaea*, especially with *M. calophylla* of the Sierra Nevada de Santa Marta of Colombia. Indeed, *Macrocarpaea calophylla*, material of which has not been available to me for study, may prove to be a species of *Chorisepalum*. Gilg described the calyx-lobes of *Macrocarpaea*

[1] Received May 14, 1947.

calophylla as being distinct nearly to the base, the fundamental character of *Chorisepalum*. Gleason and Wodehouse considered *Macrocarpaea* as a possible relative of *Chorisepalum*, but decided against such a relationship since *Macrocarpaea* generally has a "prominent calyx-tube with usually short and rounded lobes," and an invariably 1-celled ovary. Moreover, no species of that genus of Andean shrubs have aristate petals.

Wodehouse provided a detailed description of the pollen-grains of *Chorisepalum ovatum* at the time the genus was first described, and gave a line drawing of a grain. No affinity with other genera of the family was suggested for *Chorisepalum* on the basis of its pollen-grain morphology.

Finally it may be said that certainly the deeply divided calyx in *Chorisepalum* (cf. Fig. 1,B) sets the genus apart taxonomically from other American Gentianaceae, yet even so fundamental a character as chorisepaly vs. gamosepaly must be considered along with other morphological characters and not alone, lest undue emphasis be attached to it. It is possible, however, that chorisepaly in this genus is indicative of primitiveness among the Gentianaceae. The geographic distribution of these four species, occupying as they do geologically old land masses in South America, is perhaps pertinent in this connection.

TAXONOMY

Chorisepalum Gleason & Wodehouse, Bull. Torrey Bot. Club **58**: 452. 1931.

Simple-stemmed shrubs or subshrubs, now erect and recalling *Psychotria*, now recalling a liana with long decumbent or pendent stems, these terete or quadrangular, often nodose, leafy up to the inflorescence; leaves varying from short-ovate or lance-ovate to orbicular, entire, plane or sometimes a little undulate, now thick and with only the midrib evident, now thinner and with the veins evident on the upper surface when raised beneath, always more or less firm-coriaceous, acute or less often obtuse, all petiolate; flowers single and terminal or 3–5 in a terminal and at times dichasial cyme, green or greenish, evidently rather early withering but somewhat marcescent; calyx tending to be ovoid, the lobes distinct to the base, lance-acuminate, or narrowly oblong, obtuse, acute or contracted to a subulate tip, subequal or two calyx-lobes somewhat longer than the other three; corolla tubular or narrow-campanulate, $1\frac{1}{8}$–$1\frac{3}{4}$ times as long as the calyx, the lobes 5 (or "actually 6"), elliptic, aristate or less often rounded; stamens attached near the base of the corolla-tube and slightly exceeding it; anthers linear; ovary linear, completely 2-celled by the intrusion of the placentae; style slender, equaling the stamens; stigma bifid, its lobes narrowly elliptic; capsule splitting into 3–5 nearly distinct cartilaginous portions, each more or less spreading in age and tending to separate, rather long-persistent on the shrub. Type species: *C. ovatum* Gleason.

KEY TO THE SPECIES

Flowers solitary and terminal, large (6–7 cm long), more or less showy; leaves smooth above, the midrib evident beneath, the secondaries obscure on both surfaces.
- Calyx-lobes obtuse; corolla-lobes erect; stems nodose, more or less quadrilateral; leaves acute.....1. *C. ovatum*
- Calyx-lobes contracted to acuminate tips; corolla-lobes reflexed; stems not at all nodose, terete; leaves obtuse or barely acute.....2. *C. carnosum*

Flowers several, in cymes, smaller (2–3 cm long), not at all showy; leaves impressed-nerved above, both midrib and secondaries raised beneath.
- Corolla-lobes rounded; calyx 22–24 mm long; leaves ovate.....3. *C. psychotrioides*
- Corolla-lobes aristate; calyx 16–20 mm long; leaves orbicular.....4. *C. rotundifolium*

1. **Chorisepalum ovatum** Gleason, Bull. Torrey Bot. Club **58**: 452. 1931.

Straggling shrub about 3 m high; leaves oval, 4.5–7 cm long, 3–4 cm wide, abruptly narrowed to a small triangular obtuse apex, rounded at the base, the midrib impressed above, elevated beneath, the lateral veins obscure; flowers large, tubular, green; calyx-lobes narrowly oblong, obtuse, 30 mm long; corolla-tube 40 mm long, its lobes 25 mm long, 15 mm wide, acute and aristate, the arista 5 mm long; filaments slender 30 mm long, inserted 15 mm above the base of the corolla-tube; anthers 7 mm long; style slender, 30 mm long, the lobes of the stigma obtuse, 5 mm long; ovary narrowly linear, 12 mm long; mature fruit unknown.

Type collected at the "base of the slope of Ridge 25, 5200 feet," Cerro Duida, Venezuela,

November 26–December 16, 1928, by *G. H. H. Tate* 462 (type, NY; photo of type, USNA). The type bore but a single flower, which was removed and placed in a vial but the vial has not been located. The type sheet carries a drawing of the flower, laid open.

Chorisepalum ovatum is most closely related to *C. carnosum* of Carrao-tepuí, the two species occurring at comparable elevations on the two cerros. *Chorisepalum ovatum* has much thinner leaves than *C. carnosum*, recalling those of *Gardenia* or *Citrus*. But most striking are the very apparent differences in habit between the two species, *Chorisepalum ovatum*, as scantily known from the single sheet, having slender coarsely fissured branchlets with short internodes, *C. carnosum*, on the other hand, having elongated, almost smooth cordlike branchlets with the internodes about as long as the leaf-blades. Both species are more or less "straggling shrubs" but evidently *Chorisepalum carnosum* is much more of a climber than *C. ovatum*.

2. **Chorisepalum carnosum** Ewan, sp. nov. Fig. 1, A

Semiclimber or subepiphyte, the stems single, erect, 2–3.5 m high, scandent or nearly so, finely fissured, glabrous throughout; leaves oval, thick-coriaceous and subsucculent, narrowly revolute-margined, only the midrib evident, dark green above, pale green beneath, 5–7.5 cm long, 4.0–4.5 cm wide, barely acute or rounded, all short-petiolate, the petioles stout, 7–10 mm long; flowers solitary and terminal, large, showy, with a slight odor of musk; calyx campanulate, 5 cm long, narrowed to an acute base, the lobes triangular-lanceolate, cuspidate; corolla about 1½ times as long as the calyx, 6.5 cm long, the lobes "dull green" on back, "dull greenish" within, reflexed, the tube "bronze-lavender" within; capsule oblong-ovate, ca. 2.5 cm long, deflexed in age.

Suffrutex subscandens vel subepiphyticus 2–3.5 m altus caulibus erectis vel scandentibus procumbentisve, totis glabris et fissuratis; foliis omnibus breviter petiolatis, petiolis firmis 7–10 mm longis, laminis foliorum superiorum paulum reductis, omnibus ovalibus, vix acutis vel saepe obtusis, crasso-coriaceis et subsucculentis, margine anguste revolutis, supra lucidis saturate viridibus, subtus pallidioribus, venis secondariis utrinque obscuris, 5–7.5 cm longis, 4.0–4.5 cm latis; floribus solitariis et terminalibus, magnis et speciosis; calyce campanulato, 5 cm longo ad basim acutem contracto, lobis triangulari-lanceolatis, cuspidatis; corolla 6.5 cm longa, tubo intus pallide aeneo-purpurascenti, lobis utrimque opaco-viridibus, retroflexis; capsula oblongo-ovata, ca. 2.5 cm longa, post maturitatem deflexa.

Type collected on the southeastern portion of the base of Carrao-tepuí, altitude 1,460–1,615 meters, State of Bolívar, Venezuela, December 4–5, 1944, by *Julian A. Steyermark* 60852 (type, F; photo of type, USNA; isotype, US).

Chorisepalum carnosum is very evidently most closely related to *C. ovatum* of Mount Duida; both plants known from a single collection but amply distinct. Together they comprise a most striking species-pair, comparable to the situation in some other endemic genera of the Venezuelan cerros.

The thick-coriaceous leaves of *Chorisepalum carnosum* recall to some persons certain species of the genus *Clusia* and to others the genus *Hoya*. In any event, the leaves are highly diagnostic among the tropical American Gentianaceae and the characters are at once evident from the photograph (Fig. 1, A). The flower of the type specimen chosen for the illustration was mistakenly mounted with the shoot on the left, although it is evident from the point of attachment of the pedicel that it belonged on the shoot mounted on the right. Indeed, *Chorisepalum carnosum* and *C. ovatum* are almost unique among species of the lisianthoid genera of the New World in having a solitary terminal flower.

Steyermark remarks on the label that the species "was seen above 'Misia Kathy' camp [on the mesa between Ptari-tepuí and Sororopán-tepuí] as a dominant ground cover or understory, but at that time was seen only sterile and not collected."

3. **Chorisepalum psychotrioides** Ewan, sp. nov. Fig. 1, B, C.

Simple-stemmed shrub or subshrub 2.5–4 m high, glabrous throughout, a little glandular about the uppermost nodes, the upper internodes short, the branchlets evidently leafy; leaves ovate, mostly abruptly acute or again barely acute at tips, acute to cuneate at the base, "subcoriaceous-chartaceous," impressed-nerved and dull olive-green above and more

FIG. 1.—Two species groups of *Chorisepalum:* A, *C. carnosum* (type, *Steyermark* 60852), with single terminal flower (see text), and C, *C. psychotrioides* (type, *Steyermark* 58668), with cymes; B, same, inflorescence enlarged, showing the chorisepalous calyces.

yellowish beneath, the veins percurrent and anastomosing along the margin, prominently raised, 8–14 cm long, 5–6 cm wide, the petioles rather stout, 1–2 cm long; flowers 2–5 in terminal and dichasial cymes, the pedicels strongly flattened; calyx ovoid, 22–24 mm long, the sepals lance-acuminate, hyaline-margined below, the tips long, acicular, involute; corolla after anthesis a little longer than the calyx, evidently green when fresh, the lobes rounded; capsule oblong, the body 15 mm long, the beak 8 mm long, the fruit persistent after dehiscence.

Frutex vel suffrutex 2.5–4 m altus, caulibus simplicibus, totis glabris, supra paulo glandularibus foliosis, internodiis superioris brevibus; foliis ovatis, saepe apice breviter acutis vel vix acutis, basi acutis vel cuneatis, subcoriaceo-chartaceis, opaco-olivaceis, subtus subflavis, supra impresso-nervis, venis percurrentibus et ad marginem anastomosantibus, subtus prominentibus, 8–14 cm longis, 5–6 cm latis, petiolis crassis, 1–2 cm longis; floribus 2–5, terminalibus et cymosis, pedicellis valde compressis; calyce ovoideo, 22–24 mm longo, lobis lanceolato-acuminatis, ad basim hyalino-marginatis, apice longo, aciculari involuto; corolla post anthesin paulo longiore quam calyce, viridi (?), lobis obtusis; capsula oblonga, persistenti, 15 mm longa rostro 8 mm longo excepto.

Type collected in forested southwest-facing quebrada near Rondón Camp, Mount Roraima, State of Bolívar, Venezuela, alt. 2,040 meters elevation, September 25, 1944, by *Julian A. Steyermark* 58668 (F no. 1183945; photo, USNA).

Another collection:

VENEZUELA: Bolívar: Ptari-tepuí, forested sandstone south-facing slopes between plateau portion and "Cave Camp," 1,700–1,800 meters, *Steyermark* 59707 (F.).

Chorisepalum psychotrioides resembles *C. rotundifolium* most closely of the known species. From the latter it may be distinguished by the non-punctate leaves (cf. Fig. 1, B) as well as by their ovate, not orbicular, shape. On Ptari-tepuí, where both species occur, *Chorisepalum psychotrioides* occupies a lower altitudinal position than *C. rotundifolium*, with a hiatus of 200 meters between their areas. *Chorisepalum psychotrioides* is the only species known from Roraima.

4. **Chorisepalum rotundifolium** Ewan, sp.nov.

Shrub 1.5–3.0 m high, glabrous or subglabrous throughout, the upper internodes short, densely leafy up to the inflorescence; leaves orbicular, 3–6 cm long, the largest blades of sterile shoots short-ovate, rounded, much larger, 13 cm long, 8–10 cm wide, thick-coriaceous, impressed-nerved above, dull and punctate on both surfaces, sometimes a little puberulent beneath near the base, all short-petiolate, the petioles 2–8 mm long; flowers usually 3–5 in terminal cymes, also axillary in the uppermost axils, the pedicels terete; calyx narrowly ovoid, 16–20 mm long, the sepals lance-acuminate, scarcely if at all hyaline-margined below, the involute portion of calyx-lobes short; corolla much exceeding the calyx, green, the lobes narrowly lanceolate, about 1 cm long, acuminate to a hairlike tip; capsule oblong, the body 14 mm long, the beak (persistent style) 4 mm long.

Frutex 1.5–3 m altus, omnino glaber vel subglaber, internodiis superioribus brevibus, ad cymam dense foliosis; foliis orbicularibus, 3–6 cm longis vel laminis foliorum sterilium 13 cm longis et 8–10 latis, breviter ovatis, supra impresso-nervis, crasso-coriaceis, subtus paulo puberulentibus prope basim, utrinque opacis et punctatis, breviter petiolatis, petiolis 2–8 mm longis; floribus saepe 3–5, cymosis terminalibus et axillaribus, pedicellis teretibus; calyce anguste ovoideo, 16–20 mm longo, lobis lanceolato-acuminatis, basi vix hyalino-marginatis, apice involuto loborum brevi; corolla valde exserta, viridi, lobis anguste lanceolatis, ca. 1 cm longis, aristatis; capsula oblonga, 14 mm longa, rostro 4 mm longo excepto.

Type collected in *Bonnetia roraimae* forest on southwest-facing shoulder, Ptari-tepuí, State of Bolívar, Venezuela, altitude 2,000–2,200 meters, November 2, 1944, by *Julian A. Steyermark* 59730 (type, US; isotype, F).

VENEZUELA: Bolívar: Sororopán-tepuí, crest of cerro between east and west end, alt. 2,255 meters, Nov. 14, 1944, *Steyermark* 60139 (F).

Chorisepalum rotundifolium is certainly most closely related to *C. psychotrioides* of Roraima and Ptari-tepuí. In addition to the *differentiae* given in the key, the two species may be readily identified even in sterile condition by the punctate character of the leaves of *C. rotundifolium*.

ECONOMIC ENTOMOLOGY.—*The effect of particle size and velocity of movement of DDT aerosols in a wind tunnel on the mortality of mosquitoes.*[1] RANDALL LATTA, LAUREN D. ANDERSON, and E. E. ROGERS, U. S. Bureau of Entomology and Plant Quarantine, and V. K. LAMER, S. HOCHBERG, H. LAUTERBACH, and I. JOHNSON, Columbia University. (Communicated by C. F. W. MUESEBECK.)

This paper reports a continuation of the cooperative work between the Bureau of Entomology and Plant Quarantine and the Central Aerosol Laboratory of Columbia University on the influence of the size of uniform particle size oil aerosols of DDT upon mosquitoes. In the first paper[2] the mosquitoes and the aerosols were maintained in chambers so that an essentially static atmosphere prevailed. In the present paper this restriction is removed by subjecting the test insects to an aerosol moving in a wind tunnel at carefully defined speeds of motion.

It was recognized that aerosols applied in the open as large clouds, and drifted across an area to be treated, might be governed by somewhat different factors than were those applied in confined atmospheres. In the open, movement by drifting would far exceed gravitational fall. Furthermore, in drifting by wind movement, all particles could be assumed to have the same velocity regardless of size, within the range of sizes capable of remaining airborne for any length of time.

The apparatus for the generation of these homogeneous aerosols and the optical instruments and methods of measuring their particle size which had been developed by LaMer, Sinclair, Hochberg, and others in the Central Aerosol Laboratory in previous studies relating to various types of smokes were utilized in this study. A detailed description is given in O.S.R.D. Reports Nos. 119 and 1668, and N.D.R.C. Div. B Report No. 57.

In the previous work on confined atmospheres, exposures of 10 to 30 minutes in aerosol concentrations of around 100 micrograms per liter, of oil containing 8 percent of DDT were necessary to cause high mortalities when particles of 1 micron or less in diameter were used. On the other hand, exposures of ½ to 2 minutes in aerosol concentrations of around 25 micrograms per liter produced high mortality when particles were 5 to 16 microns in diameter. When Ct (concentration × time of exposure) values which produced 50 per cent mortality of females were plotted against particle size, the toxicity was shown to be increased 250-fold when the diameter of the particle was increased from 0.33 to 11 microns. It was shown also that this curve corresponds to a curve in which the time necessary for an aerosol to settle out of 1 cc is plotted against particle size, as calculated according to Stokes's law. This finding indicated that the mortality of resting insects caused by aerosols in confined atmospheres resulted from deposition of the particles on the insects as a result of gravitational settling, and could be directly correlated with Stokes's law; i.e., the toxicity was proportional to the square of the diameter of the particle up to about 16 microns diameter, the concentration of DDT and the exposure time being held constant.

Shortly after the completion of the work on confined atmospheres, a theoretical treatment of the extent of deposition of wind-borne aerosols upon objects of various

[1] This work was conducted under transfers of funds, recommended (1) by the Committee on Medical Research, from the Office of Scientific Research and Development to the Bureau of Entomology and Plant Quarantine, and (2) by the National Defense Research Committee, from the Office of Scientific Research and Development to Columbia University under Contract OEMsr 1388. It is based upon Report No. 5566 of the O.S.R.D. dated July 30, 1945. This report is on file with the Insect Control Committee of the National Research Council and is available for reference upon application to that agency. Received June 2, 1947.

[2] LAMER, V. K., S. HOCHBERG, et al. *The influence of the particle size of homogeneous insecticidal aerosols on the mortality of mosquitoes in confined atmospheres.* (In press.) This paper is based upon O.S.R.D. Report No. 4447, to which the reader is referred for more details of execution and of history of subject.

geometrical shapes by Winsche[3] based upon Sell's[4] original studies became available. This study indicated to us that the deposition upon insects, and hence the toxicity of a moving mass of aerosol, might likewise be expected to be dependent upon the square of the radius (or diameter) of the particle and in addition upon the first power of the velocity of the wind propelling the aerosol.

The series of experiments reported in this communication were therefore undertaken to test this conclusion by direct measurements in a wind tunnel. This study was performed at the Bureau laboratories, Agricultural Research Center, Beltsville, Md., between January 10 and May 2, 1945. The Central Aerosol Laboratory at Columbia University was responsible for all the physical and chemical phases of the program and the Bureau for all biological phases, as well as quarters and all permanent installations. Evaluation of results was done jointly.

[3] WINSCHE, WARREN E. *The deposition of non-volatile aerosol clouds in open and forested areas.* N.D.R.C. Report No. 10.4–55. 1944.

[4] SELL, W. [*Spray precipitation in an uncombined body and in an air filter.*] Ver. Deutsche Ingen. Forschungsarb., V.D.I Verlag, 347. Berlin. 1931.

TECHNIQUE

Aerosols uniform in particle diameter were introduced into the mouth of a small wind tunnel (Fig. 1) in which a known air flow was maintained. Adult mosquitoes in cages were exposed in the tunnel to measured quantities of the aerosol and observed for mortality.

The wind tunnel was constructed of composition board and was 1 foot square in cross section by 32 feet in length. The air movement was provided by a suction blower attached to the end of the tunnel. The air flow was adjusted by a slide damper placed just ahead of the blower and measured by determining the pressure drop across an orifice placed in the tunnel ahead of the damper. The pressure drop was read by means of an inclined manometer. This arrangement allowed air flows ranging from 1 to 16 m.p.h. to be determined with accuracy. The calibrations of the velocity of air flow in respect to the

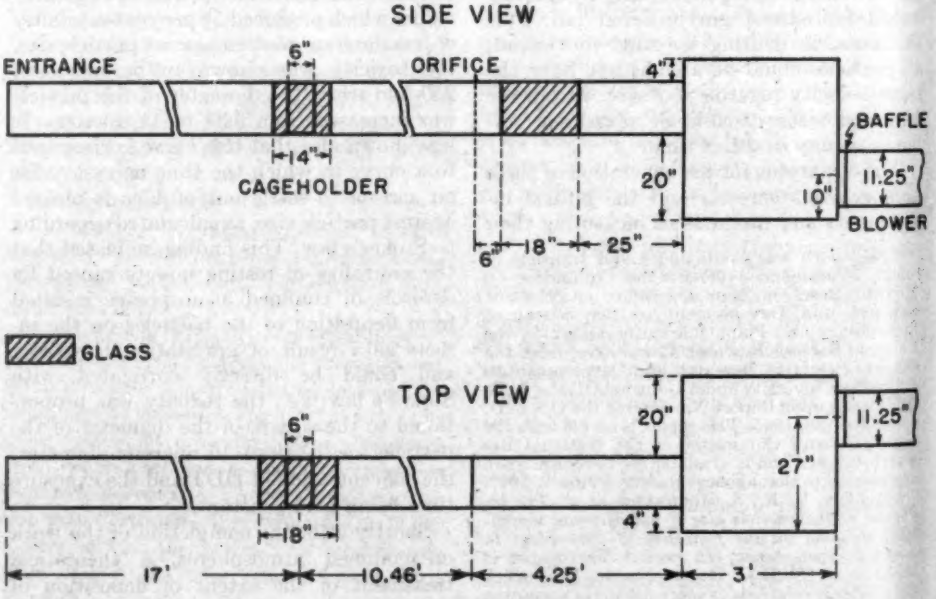

FIG. 1.—Diagram of wind tunnel used in these experiments.

radial distribution of flow in the tunnel, as well as adjustments of the orifice diameter and pressure, were performed by K. C. Hodges and J. C. Rowell, of the Central Aerosol Laboratory. Their findings, which proved to be in good agreement with the predictions of air flow theory, are fully discussed in O.S.R.D. Report No. 5566. This report should be consulted by those interested in the details of constructing wind tunnels.

At a point 17 feet from the mouth of the tunnel, a cage holder (Fig. 2) into which a

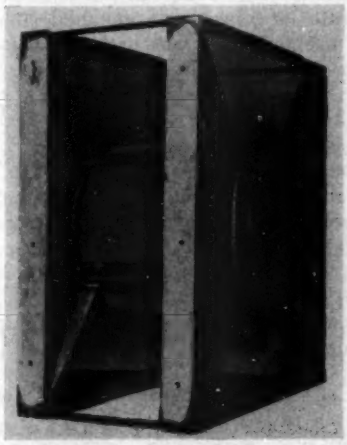

Fig. 2.—Square frame placed across the wind tunnel to hold the insect exposure cage in the exact center. The cage is in place.

cage holding mosquitoes could be inserted, was placed in the tunnel. The cages were cylindrical, 6 inches in diameter and 6 inches long, with both ends removable. The side walls of the cages were lined with 20-mesh wire cloth. The covers were made of 16-mesh wire cloth. The holder, which occupied the entire cross section of the tunnel, was covered front and back with 16-mesh wire cloth in order to equalize resistance across the tunnel. Glass windows were inserted on all sides of the tunnel at the location of the cage, so that observations could be made during treatment. Access to the tunnel was through a removable panel in the top.

The mouth of the tunnel was equipped with a flared metal collar and a mixing baffle. The distance from the mouth to the position of the cage was sufficient to allow the aerosol to be distributed uniformly across the tunnel. The uniformity of distribution of the aerosol in the cylindrical cage was confirmed by observing, through the windows, the flow of a screening smoke.

The aerosols were prepared in a LaMer-Sinclair homogeneous aerosol generator, similar to the one used in the previous studies relative to aerosols in confined atmospheres except for some modifications for preparing more homogeneous aerosols in the large particle range. In this generator DDT, dissolved in an oil having a narrow boiling-point range and a vapor pressure comparable to that of DPT, was vaporized in glass vessels, and mixed with known amounts of air and with a controllable number of nuclei. The diluted vapor was allowed to cool and condense upon these nuclei under carefully regulated conditions. The particle size was controlled by regulating the vapor pressure by adjusting the temperature and the number of nuclei. The nuclei were produced by heating sodium chloride deposited upon electrically heated nichrome wire.

Two methods were used to determine the average particle diameter of an aerosol, rate of settling and impingement on a waved slide. In the first method the average time for 10 particles to settle 0.5 cm in quiet air was determined, and the particle diameter calculated from this figure. In the second method a slide was waved in the aerosol stream at the mouth of the tunnel, and a sample of at least 200 particles measured. The average diameter of the particles was calculated on the basis that the probability that a particle in the aerosol will adhere to the slide is in proportion to the square of its diameter. The aerosols were uniform in size. Generally 90 percent of the mass would fall in a range ± 10 percent from the average.

The output of the generator was constant, once it was properly adjusted for a desired particle size. Prior to a series of treatments the aerosol was drawn through a weighed glass-wool filter for a measured period of about 10 minutes. The filter was reweighed and the amount of aerosol gen-

erated per minute computed. The aerosol deposited on the filter was analyzed for DDT content. The content of DDT in the aerosol was usually somewhat different from the content in the unvaporized oil, owing to an unavoidable slight difference in vapor pressure. Different dosages of aerosol could be applied by varying the time during which the aerosol was introduced into the tunnel. The rate of generation was usually between 5 and 15 mg of oil-DDT aerosol per minute. The generator was placed above the mouth of the tunnel, with the outlet in the center of the tunnel opening.

Adult *Aedes aegypti* mosquitoes[5] ranging 4 to 7 days old were used in all tests. The mosquitoes were kept in a small insectary well removed from the wind tunnel. For individual tests mosquitoes were transferred from stock cages into one of the cylindrical cages used in the wind tunnel. The test cage was then transported to the tunnel in a closed fibreboard box and immediately placed in position in the tunnel. At the end of the treatment the cage was transported back to the insectary in the same manner, and the mosquitoes were immediately emptied into a clean cage for observation of mortality. Adequate control samples were handled in the same manner as treated ones, except for exposure to the aerosol.

In each series one control sample was exposed to air flow in the tunnel for a period equal to or greater than the most rigorous exposure in the treated series. When there was no wind the mosquitoes flew about the cage, but once air flow was started through the tunnel there was little or no activity. At low velocities they tended to congregate on the front screen of the cage, but at 16 m.p.h. they were blown against the rear screen and held there by the air flow. The control experiments showed that mosquitoes were not injured by air speeds of 16 m.p.h.

Mortality counts were made the day following treatment. The mortality of males was invariably greater than that of females, but only data on female mortality were used in the final evaluation of the results.

Every precaution was taken to prevent contamination of the cages and the insectary with DDT. The test cages were washed with acetone, and the holding cages thoroughly scrubbed with water after each using.

[5] The mosquitoes were supplied by Abby Casanges and associates in the Bureau of Entomology and Plant Quarantine.

RESULTS

Fifteen series of tests were made with homogeneous aerosols. The particle diameter of these aerosols ranged from 1.12 to 20.4 microns. Since the particle size and the rate of generation remained constant once the generator was properly adjusted, all tests with a given particle size were made as a group when possible. A group usually consisted of four exposures each at velocities of 2, 4, 8, and 16 m.p.h.

The mortality produced by each particle size is given in table 1. The amount of aerosol is in terms of the total amount admitted to the tunnel. Since it all passed the point where the cage of insects was exposed, it represents the amount per square foot, as the cross section of the tunnel was 1 square foot.

DISCUSSION

For each particle diameter a set of curves was drawn, one for each wind velocity, relating the percent mortality of females to the number of milligrams of aerosol passed through the tunnel. From each curve a figure for the amount of aerosol required to kill 50 percent of the females was obtained by interpolation. Since the DDT content was determined for each run, the amount of DDT for 50 percent mortality of females can be derived from these figures. Such data for 14 particle sizes are given in table 2.

The curves fall into three types. Small particles yield curves similar to Fig. 3, large particles curves similar to Fig. 4, and intermediate sizes curves similar to Fig. 5. In the first case the amount of aerosol required to pass through the tunnel to kill any given fraction of the females is inversely proportional to the wind velocity; in the second case it is independent of the wind velocity, and in the third case it is inversely proportional to the wind velocity for low

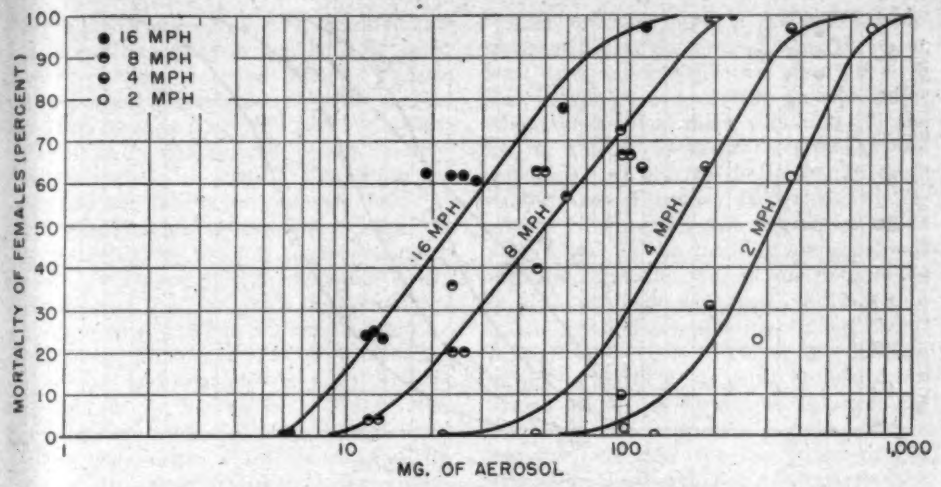

FIG. 3.—Dosage-mortality curves for a homogeneous aerosol of 2.5 microns particle diameter, moving at velocities of 2,4,8, and 16 m.p.h.

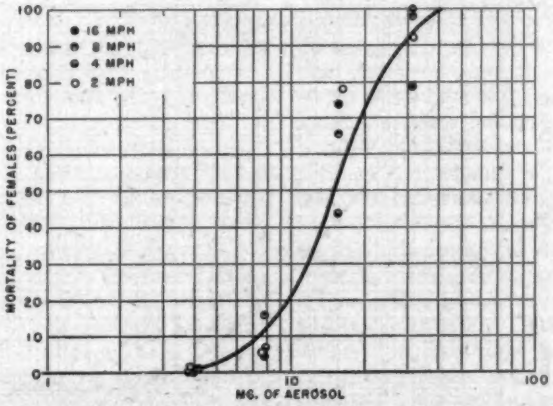

FIG. 4.—Dosage-mortality curve for a homogeneous aerosol of 20.4 microns particle diameter, moving at velocities of 2, 4, 8, and 16 m.p.h.

wind velocities and independent of wind velocity for high wind velocities.

The differences in mortality produced by aerosols with different particle size at a constant rate of motion, or by different rates of motion with an aerosol of constant size, were ascribed to differences in the rate of deposition of the particles on the insects induced by the above variations. In other words, the differences were due to a change in the percentage of particles which adhered to the insects in their paths, as a result of a change in size or velocity of the particle. It is easily observed that a reduction in particle size tends to reduce deposition. Smoke or fog, consisting of very fine particles, tends to follow the air streamlines around a body, and only a small fraction actually strikes the body. On the other hand, larger particles, as illustrated by rain, practically all strike bodies in their paths. It has been demonstrated also that an increase in the velocity of particles also increases the rate of deposition. In fact, it

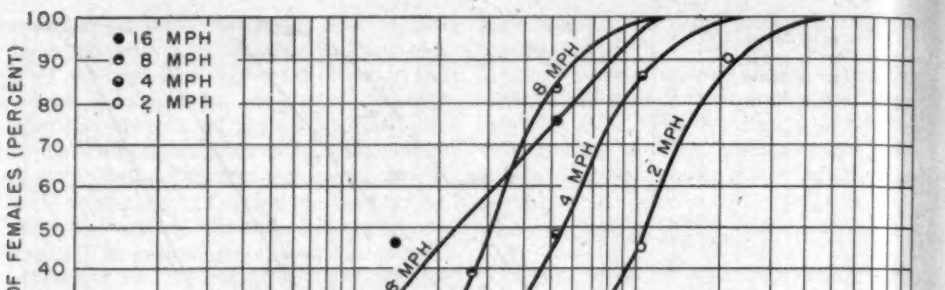

FIG. 5.—Dosage-mortality curves for a homogeneous aerosol of 5 microns particle diameter, moving at velocities of 2, 4, 8, and 16 m.p.h.

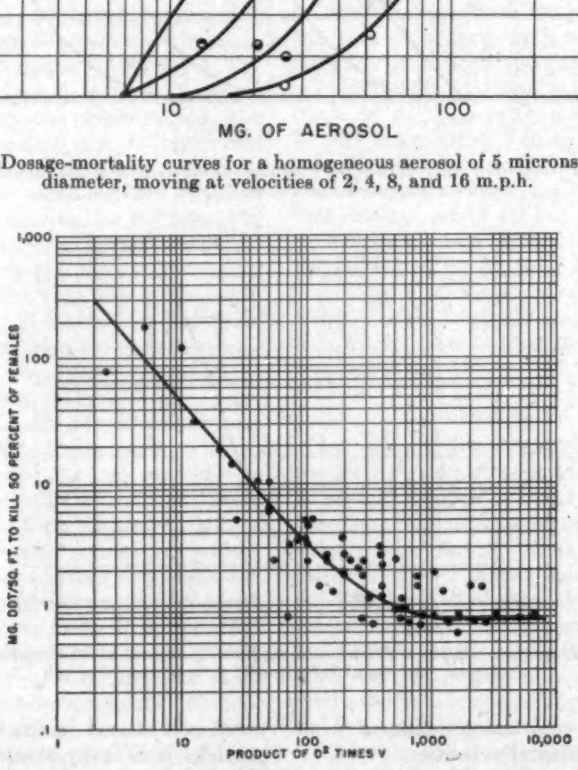

FIG. 6.—The effect of the product of D^2v on the amount of DDT required to produce 50 percent mortality of females.

is possible to remove practically all the particles of an aerosol by impingement against a surface with sufficient velocity.

In the range of the smaller particle sizes that were tested, the mortality with a given amount of DDT was dependent upon the particle size and velocity, i.e., proportional to the square of the diameter and the first power of the velocity. In the range of the largest particle sizes that were tested, the mortality with a given amount of DDT was not affected by a change in particle size or velocity. This condition was considered to be above the point where the maximum rate of deposition occurred. The influence of particle size and velocity upon

mortality decreased as the maximum rate of deposition was approached. In the range where particle size and velocity exerted their greatest effect on mortality, the amount of DDT required for 50 percent mortality was inversely proportional to the velocity; in other words, the rate of deposition was doubled when the velocity was doubled.

Since Winsche (1944) indicated that the deposition on an insect might be dependent upon the square of the diameter of the particle and the first power of the velocity, the amount of DDT in milligrams is plotted against the product of D^2v (D is measured in microns and v in miles per hour) for each particle size, in Fig. 6. At the lower values of D^2v, a single line plotted through these values has a slope of -1, which gradually changes to a slope of 0 at the higher values. This signifies that further changes in velocity or particle size do not affect the mortality.

After a certain value of D^2v is reached, the amount of insecticide required becomes independent of the velocity and diameter, but it is evident from statistical considerations[6] that eventually a point will be reached in particle size where a decrease in effectiveness will begin to occur. This is a consequence of the laws of probability, which come into prominence when a point is reached where a small number of particles are sufficient to kill an insect. When large numbers of particles are necessary each insect receives substantially the same number of particles and only the susceptibility of the insect determines the median lethal dose. On the other hand, when the particle number is small a small variation in number of particles represents a large percentage variation in toxic dosage. This effect, superimposed upon the susceptibility of the insect, tends to increase the median lethal dose.

Aside from the statistical considerations, it is evident that if a particle contains more than a lethal dose all the excess DDT in each particle is wasted. This factor will increase the apparent median lethal dose as determined experimentally and can become very significant.

[6] RODEBUSH, W. H. *Statistical considerations in the use of DDT aerosols.* O.S.R.D. Report No. 4757.

The optimum particle size for aerosols dispersed from the ground depends on at least two factors—(1) the most effective size in relation to deposit on the insect when the particle reaches it, and (2) the loss of aerosol by deposit on foliage and settling on its way to the insect. In these studies only the first factor was determined. However, certain known effects of particle size on the travel of aerosol clouds through vegetation permit an estimate to be made of the limits of particle size within which economical operation is feasible. If the aerosol cloud is to travel any distance at all, the particle size must be held down to one which will carry this distance. For maximum effect it must be held up to a size that will give the maximum rate of deposit on the insect. For *Aedes aegypti* the upper limits can be indicated by reference to Fig. 6. These limits would be at a point where D^2v is 300 to 1,000 (for example, 13 micron diameter at 5 m.p.h., or 10 micron diameter at 8 m.p.h., etc.). particles larger than this would not increase the efficiency of the aerosol when it reaches the insect, as a smaller percentage of such particles would carry to the insect.

Since the amount of DDT introduced into the tunnel was known, an approximate toxic dose of 0.03 microgram for a female of median susceptibility could be calculated from the data. For this purpose the area of a mosquito was assumed to be 0.03 cm^2, and the quantity of DDT to be 0.8 mg per square foot for large particles and high velocities where practically all particles would impinge on the insect. This quantity is contained in a single spherical particle of pure DDT (density 1.4) of a volume of 2.14×10^{-5} cm^3 or of a diameter of 34.4 microns. With a 10 percent solution of DDT, a 30×10^{-5} cm^3 droplet is required, which would be contained in a particle 83 microns in diameter.

The mortality curves obtained in these tests showed the amount of DDT causing 95 percent mortality to be between two and four times that for 50 percent mortality. Therefore, the approximate dose for 95 percent mortality would be between 6×10^{-5} and 12×10^{-5} mg; i.e., 0.06 to 0.12 microgram per insect. This would be a maximum amount, because in these cal-

culations the deposition of aerosol on the wire screen of the insect cage and the amounts deposited on the walls of the tunnel have not been considered. Neither of these quantities was measured. That deposited on the walls of the tunnel was minimized by the elimination of depressions and rough areas. It is estimated from Stokes's law that the error due to settling would be greatest with the largest particles and lowest wind velocities and would amount to less than 20 percent at 2 m.p.h. or less than 3 percent at 16 m.p.h. Deposition on the wire screen would be less than 35 percent, since the wires of the mesh occupy approximately 35 percent of the area of the screen.

The median lethal doses, as given in table 2, fall within a range of 0.5 to 2 times the central tendency as shown in Fig. 6. It is therefore considered that the total experimental error, including the variation in susceptibility of the mosquitoes from day to day, is within these limits.

CONCLUSIONS AND ANALYSIS

The following conclusions on the effect of particle size and the speed of motion were reached by comparing the mortalities produced by particles varying between 1.12 and 20.4 microns in diameter, under various speeds between 2 and 16 m.p.h. The first four conclusions are associated exclusively with physical factors, and would apply to any insect and any insecticide.

1. The rate of deposition of an aerosol upon an insect, as evidenced by the mortality, is affected by the particle diameter and the velocity.

2. Under conditions where only a small fraction of the particles deposit on insects in their path (small particles and low wind velocity), the amount of aerosol required is inversely proportional to the product of the square of the diameter and the wind velocity.

3. The increase in effectiveness with increase in particle size and velocity continues until practically all particles are deposited on an insect in their path. Thereafter, further increase in particle size or velocity is ineffective.

4. The mortalities caused by different velocities, or different particle sizes, depend on the product of the velocity and the square of the particle diameter. Doubling the particle diameter has the same effect on mortality as quadrupling the velocity.

5. Total deposition of the aerosol on *Aedes aegypti* females is approached when D^2v (D is measured in microns and v in miles per hour) exceeds 1,000. However, there is little difference in doses for D^2v values of 300 to 1,000. (For instance, where $D=1$ micron and $v=5$ m.p.h., $D^2v=5$ and incomplete deposition resulted. Where $D=25$ microns and $v=2$ m.p.h., $D^2v=1{,}250$ and practically complete deposition resulted, as evidenced by the mortality obtained.)

6. The approximate amount of DDT that should be deposited on an *Aedes aegypti* female of median susceptibility to cause mortality was determined to be 0.03 microgram. This quantity is contained in a droplet of 10 percent DDT solution 83 microns in diameter.

SUMMARY

In order to determine the influence of wind velocity and particle size on the toxicity of an oil aerosol bearing DDT to adult insects, cages of *Aedes aegypti* mosquitoes were exposed, in a wind tunnel, to aerosols of uniform and known particle size at wind speeds of 2, 4, 8, and 16 m.p.h. The diameter of the aerosol droplets ranged from 1.12 to 20.4 microns.

The quantity of DDT which must pass through a given cross-sectional area of the tunnel to kill 50 percent of the females is a simple function of D^2v, the product of the square of the diameter D of the droplets and the wind velocity. For small values of D^2v the quantity required is inversely proportional to D^2v; for large values it is independent of D^2v.

The results are analyzed on the basis that differences in mortality are produced by differences in rates of deposition of the aerosol, and on this basis a figure was obtained for the median lethal dose for females of 3×10^{-5} mg of DDT. This is contained in a single particle of a 10 percent solution 83 microns in diameter, or of 100 percent DDT 34 microns in diameter.

TABLE 1.—MORTALITY CAUSED BY PARTICLE SIZES OF AEROSOL RANGING IN DIAMETER FROM 1.12 TO 20.4 MICRONS, AT VELOCITIES OF 2, 4, 8, AND 16 M.P.H.

Particle diameter	Velocity	Total amount of aerosol	Content of DDT	Amount of DDT	Female mosquitoes	Mortality
Microns	*M.p.h.*	*Mg.*	*Percent*	*Mg.*	*Number*	*Percent*
1.12	16	48.2	11.55	5.6	24	8
		96.4	11.55	11.1	70	27
		114	10.42	11.9	64	8
		193	11.55	22.3	74	60
		223	12.4	27.6	72	92
		386	11.55	44.6	127	95
	8	193	11.55	22.3	12	0
		223	12.4	27.6	65	5
		386	11.55	44.6	103	9
		698	10.78	75.2	53	25
		750	10.42	78.2	121	19
	4	223	12.4	27.6	82	2
		386	11.55	44.6	117	2
		750	10.42	78.2	141	5
		771	11.55	89.0	10	10
		1308	10.78	141.0	56	39
	2	223	12.4	27.6	60	0
		386	11.55	44.6	55	11
		750	10.42	78.2	129	100
		771	11.25	86.7	60	60
		1308	10.78	141.0	52	100
	16	None	—	—	94	0
					81	0
					41	0
2.5	16	6.5	11.15	.72	62	0
		13	11.15	1.45	54	24
		14.6	12.55	1.83	73	25
		19.2	10.1	1.94	119	63
		26	11.15	2.9	47	62
		29.2	12.55	3.66	124	60
		58.4	12.55	7.33	110	78
		116.8	12.55	14.66	97	98
		233.2	12.55	29.27	75	100
	8	13	11.15	1.45	102	4
		23.2	9.25	2.15	33	36
		26	11.15	2.9	40	20
		46.4	9.25	4.29	79	41
		52	11.15	5.8	30	63
		60	10.1	6.06	53	57
		91.8	9.25	8.49	59	73
		104	11.15	11.60	54	67
		208	11.15	23.19	37	100
	4	23.2	9.25	2.15	107	0
		46.4	9.25	4.29	54	0
		91.8	9.25	8.49	115	10
		185.6	9.25	17.2	47	64
		192	10.1	19.39	58	31
		371.2	9.25	34.34	58	97
	2	96.0	10.1	9.7	62	2
		197.2	9.25	18.24	17	0
		288	10.1	29.09	52	31
		371.2	9.25	34.34	23	61
		720	10.1	72.72	91	97
	16	None	—	—	48	0
					111	0
					132	0

Particle diameter	Velocity	Total amount of aerosol	Content of DDT	Amount of DDT	Female mosquitoes	Mortality
Microns	*M.p.h.*	*Mg.*	*Percent*	*Mg.*	*Number*	*Percent*
3.72	16	92.8	2.42	2.24	114	48
		185.6		4.49	42	86
		371.2		8.98	60	100
	8	185.6		4.49	75	44
		371.2		8.98	49	96
		742.4		17.96	84	100
	4	185.6		4.49	36	21
	2	371.2		8.98	20	5
4.48	16	4.78	9.17	.44	8	0
		9.55		.88	45	36
		19.1		1.75	62	79
		38.2		3.50	27	85
	8	9.55		.88	17	18
		19.1		1.75	99	68
		38.2		3.50	39	85
		76.4		7.0	140	93
	4	9.55		.88	31	3
		19.1		1.75	16	25
		38.2		3.50	48	52
		86.0		7.89	113	75
	2	19.1		1.75	16	0
		38.2		3.50	47	0
		76.4		7.0	92	24
		152.8		14.0	18	83
	16	None			68	0
					12	0
5.0	16	6.5	5.8	.38	53	0
		13		.75	124	46
		26		1.51	59	39
		52		3.02	24	75
	8	6.5		.38	49	0
		13		.75	76	13
		26		1.51	62	39
		52		3.02	29	83
	4	19.5		1.13	61	13
		26		1.51	61	10
		52		3.02	99	48
		104		6.03	29	86
	2	26		1.51	74	3
		52		3.02	52	15
		104		6.03	49	45
		208		12.1	29	90
		None	—	—	45	0
6.0	16	8	9.22	.74	23	39
		32		2.95	59	98
		64		5.9	29	100
	8	8		.74	53	4
		16		1.48	64	22
		32		2.95	104	71
		64		5.9	5	60

TABLE 1.—(*continued*)

Particle diameter	Velocity	Total amount of aerosol	Content of DDT	Amount of DDT	Female mosquitoes	Mortality
Microns	*M.p.h.*	*Mg.*	*Percent*	*Mg.*	*Number*	*Percent*
	4	8		.74	43	0
		16		1.48	35	29
		32		2.95	47	53
		64		5.9	7	71
	2	8		.74	47	0
		16		1.48	49	6
		32		2.95	31	48
		64		5.9	8	75
		None			33	0
7.0	16	8.1	7.64	.62	31	13
		16.2		1.24	47	43
		32.4		2.47	21	72
		64.8		4.95	38	79
	8	8.1		.62	58	0
		16.2		1.24	40	20
		32.4		2.47	56	50
		64.8		4.95	46	80
	4	8.1		.62	65	0
		16.2		1.24	57	12
		32.4		2.47	79	66
		64.8		4.95	25	72
	2	8.1		.62	72	0
		16.2		1.24	75	1
		32.4		2.47	58	29
		64.8		4.95	91	81
		None			87	0
7.1	16	.45	9.5	.04	30	0
		.91		.09	66	0
		1.81		.17	114	1
		3.63		.34	90	1
		7.26		.69	91	7
	8	.91		.09	41	0
		1.81		.17	31	0
		3.63		.34	88	0
		7.26		.69	93	9
		14.51		1.38	83	42
	4	3.63		.34	52	0
		7.26		.69	92	1
		14.51		1.38	102	54
		29.02		2.76	75	61
		58.04		5.51	77	78
	2	7.26		.69	30	0
		14.51		1.38	45	33
		29.02		2.76	196	62
		58.04		5.51	10	10
		116.08		11.03	141	87
		None			27	0
8.0	16	4.16	7.62	.32	84	0
		8.33		.63	99	47
		16.66		1.27	80	50
		33.32		2.54	44	84
		66.64		5.08	73	96
	8	4.16		.32	76	0
		8.33		.63	34	29
		16.66		1.27	51	71
		33.32		2.54	71	78
		66.64		5.08	80	92
	4	4.16		.32	33	0
		8.33		.63	40	12
		16.66		1.27	29	45
		33.32		2.54	20	75
		66.64		5.08	68	100
	2	4.16		.32	60	0
		8.33		.63	27	11
		16.66		1.27	36	44
		33.32		2.54	45	71
		66.64		5.08	122	90
		None			80	0
10.0	16	9.6	5.0	.48	74	31
		19.3		.96	93	85
		38.5		1.92	62	94
	8	9.6		.48	54	22
		19.3		.96	64	69
		38.5		1.92	38	92
	4	9.6		.48	157	0
		19.3		.96	104	16
		38.5		1.92	82	89
	2	9.6		.48	110	0
		19.3		.96	130	11
		38.5		1.92	130	63
		None			102	0
11.4	16	10.1	6.67	.67	80	0
		20.2		1.35	50	66
		40.5		2.70	68	69
		60.8		4.06	48	81
		60.8		4.06	50	82
	8	10.1		.67	97	0
		20.2		1.35	96	27
		40.5		2.70	70	60
		60.8		4.06	53	42
	4	10.1		.67	103	0
		20.2		1.35	235	4
		40.5		2.70	127	54
		60.8		4.06	59	46
	2	10.1		.67	115	1
		20.2		1.35	114	0
		40.5		2.70	100	0
		60.8		4.06	69	80
		None			97	0

TABLE 1.—(*continued*)

Particle diameter	Velocity	Total amount of aerosol	Content of DDT	Amount of DDT	Female mosquitoes	Mortality
Microns	*M.p.h.*	*Mg.*	*Percent*	*Mg.*	*Number*	*Percent*
11.9	16	13.8	4.8	.66	127	54
		19.3		.93	107	75
		22.1		1.06	222	79
	8	5.5		.26	99	23
		22.1		1.06	125	82
	4	5.5		.26	65	3
		13.8		.66	148	53
		27.6		1.32	141	93
	2	5.5		.26	112	1
		13.8		.66	198	70
		22.1		1.06	152	89
		None			87	2
13.0	16	5.1	3.0	.15	80	0
		10.2		.31	65	17
		20.4		.61	58	47
		40.8		1.22	78	64
	8	5.1		.15	67	3
		10.2		.31	65	23
		20.4		.61	52	58
		40.8		1.22	41	76
	4	5.1		.15	151	0
		10.2		.31	88	5
		20.4		.61	60	35
		40.8		1.22	42	57
	2	5.1		.15	45	0
		10.2		.31	62	2
		20.4		.61	71	46
		40.8		1.22	86	91
		None			84	1
17.8	16	12.6	3.45	.43	21	24
		25.3		.87	117	54
		50.5		1.74	72	72
	8	12.6		.43	51	0
		25.3		.87	46	17
		50.5		1.74	48	56
	4	12.6		.43	68	1
		25.3		.87	45	4
		50.5		1.74	42	67
	2	12.6		.43	51	0
		25.3		.87	39	38
		50.5		1.74	34	88
		None			38	5
20.4	16	3.9	5.8	.23	68	0
		7.8		.45	20	5
		15.6		.90	42	74
		31.2		1.81	29	79
	8	3.9		.23	49	0
		7.8		.45	58	16
		15.6		.90	83	66
		31.2		1.81	41	98
	4	3.9		.23	39	0
		7.8		.45	32	6
		15.6		.90	18	44
		31.2		1.81	42	100
	2	3.9		.23	127	1
		7.8		.45	31	6
		16.9		.98	67	78
		31.2		1.81	28	93
		None			45	0

TABLE 2.—MILLIGRAMS OF DDT PRODUCING 50 PERCENT MORTALITY OF FEMALE MOSQUITOES AS DETERMINED BY MORTALITY CURVES PLOTTED FROM PERCENTAGES GIVEN IN TABLE 1

Particle diameter	Milligrams of DDT required at speeds of			
	16 M.p.h.	8 M.p.h.	4 M.p.h.	2 M.p.h.
Microns				
1.12	18.4	126.0	184.0	80.5
2.50	2.35	5.90	14.2	32.0
3.72	2.4	5.03	—	—
4.48	1.15	1.29	3.45	10.3
5.0	1.45	1.74	3.24	6.38
6.0	1.15	2.30	2.67	3.13
7.0	1.44	2.2	1.9	3.49
7.1	—	—	1.50	1.80
8.0	.836	.912	1.44	1.6
10.0	.59	.70	1.20	1.75
11.4	1.44	1.94	2.48	2.08
11.9	.62	.62	.62	.62
13.0	.705	.705	.705	.705
17.8	.83	1.41	1.31	.99
20.4	.87	.87	.87	.87

ZOOLOGY.—*Notes on Mexican amphibians and reptiles.*[1]

HOBART M. SMITH, University of Illinois. (Communicated by HERBERT FRIEDMANN.)

Recent acquisitions by the U. S. National Museum include a number of amphibians and reptiles of special interest from Mexico. Most of them were secured, incidental to archeological labors, by Dr. Matthew W. Stirling. The remainder were collected by Dr. W. F. Foshag. Included are two state records (of *Lepidophyma f. flavomaculatum* from Veracruz and *Oxybelis aeneus auratus* from Morelos), a few rarities such as *Syrrhophus verruculatus*, and one subspecies (*Ficimia publia taylori*, n. subsp.) hitherto overlooked and unnamed.

Localities and dates of capture are recorded in detail in the accounts of each form, with the exception of San Lorenzo, where a large proportion was taken by Dr. Stirling between February and April, 1946. This small town is on the Río Chiquito, in the southern part of the state of Veracruz, municipality of Acayucán, about 17 air miles directly southeast of the city of Acayucán (see map in *On the trail of La Venta man*, by Matthew W. Stirling, Nat. Geogr. Mag. 91 (2): 137-172, illus. 1947).

Rhinophrynus dorsalis Duméril and Bibron

Two adult specimens (nos. 123542–3) are from San Lorenzo, Veracruz. The single female has small eggs in the ovaries.

Bufo cristatus Wiegmann

Five half-grown specimens (nos. 123516–20) are from San Lorenzo, Veracruz. The species differs from *B. valliceps*, which it closely resembles, in having an occipital (parietal) crest as high as the supraorbital and which terminates abruptly posteriorly instead of declining gradually; *B. cristatus* also possesses a more oval (instead of triangular) parotoid.

Leptodactylus labialis (Cope)

Two adult specimens (nos. 123528–9) are from San Lorenzo, Veracruz.

Leptodactylus melanonotus (Hallowell)

Six specimens (nos. 123521–7) are from San Lorenzo, Veracruz. The largest female measures 43 mm from snout to vent; largest male 39 mm. No horny excrescences are present.

Microbatrachylus hobartsmithi (Taylor)

Two specimens (nos. 122054–5) are from Río Chapaneal near Aquiapan (west of Zacualpan), México, collected February 28, 1943, by Dr. W. F. Foshag. They were found in spring seepage, under moss. One (no. 122055) is very small (12.5 mm snout to vent), the other an adult (19 mm snout to vent). The latter possesses vestiges of vomerine teeth.

Syrrhophus verruculatus (Peters)

A single specimen, 19 mm snout to vent, from San Lorenzo, Veracruz (no. 123530), is referred to this small species. It is a male measuring 19 mm snout to vent, and has been somewhat crushed; the belly skin has slipped to the rear exposing the internal organs.

If correctly allocated, this specimen is the only one known from the state of Veracruz, exclusive of the type from Huatusco. The only other species known which might be involved are *S. leprus* and *S. verrucipes*. *S. cystignathoides*, which occurs in the same general area, is easily eliminated on the basis of coloration; the present specimen is dark with very extensive light areas on the back. *S. leprus* is eliminated on the basis of belly coloration (it lacks all markings, while the San Lorenzo specimen is rather heavily stippled with dark below) and on the width of the digits (outer two fingers 1½ times as wide as digits in the present specimen, scarcely enlarged in *S. leprus*). *S. verrucipes* is eliminated on the basis of its large tympanum (two-thirds diameter of orbit, while only one-half in the San Lorenzo specimen).

Other characters agree well with available descriptions of *S. verruculatus*. The belly skin is smooth, the back feebly granular. The choanae are small.

Smilisca baudini baudini (Duméril and Bibron)

Seven specimens, of which five (nos. 123508–12) are from San Lorenzo, Veracruz, and two (nos. 118635–6) are from Río de las Playas, on the boundary of the states of Veracruz and Tabasco, taken March 1–8, 1944, by M. W.

[1] Received May 5, 1947

Stirling. All those from San Lorenzo are subadults of approximately equal size, while those from Río de las Playas are large adults. One of the latter is a male with extruded vocal pouches the other a female with well-developed ovarian eggs.

Hyla arenicolor Cope

A single specimen (no. 122051) is from San Juan del Río, Guerrero, collected February 20, 1942, by W. F. Foshag. This small hamlet is about 10 miles east of Taxco and 2 miles south of Acamixtla on the banks of the Campuzo River.

Hyla rickardsi Taylor

Three specimens (nos. 123513–5) are from San Lorenzo, Veracruz, and provide a record for a fourth locality at which the species is known. Two are adult (40 mm and 35 mm snout to vent) females with fairly well developed eggs in the abdomen. Their dorsal coloration is a reddish gray-brown; indistinct, small, scattered dark flecks are present on the back, and a dark, V-shaped interorbital bar is feebly indicated. The juvenile (25.5 mm) is similarly colored, except there is a vague darker area covering much of the middle of the back; the interorbital dark bar is very distinct; the limbs are distinctly banded, and a very conspicuous short, narrow white transverse bar, preceded and followed by an equally narrow dark bar, is present immediately in front of the anus. The latter mark is visible although less well defined in one of the adults, and is absent in the other.

Rana pipiens austricola (Cope)

Ten juvenile specimens (nos. 123531–40) are from San Lorenzo, Veracruz. The largest measures 39 mm, the smallest 35 mm snout to vent. In dorsal pattern, snout length, and presence of dermal plicae they closely resemble Texan specimens of *R. p. berlandieri*, but they differ in the possession of dark mottling at least on the lips and posteroventral surface of the thighs; the mottling in some covers the entire throat and under side of the legs.

This race is envisioned as an Atlantic coastal form extending from northern Mexico (where it meets *R. p. berlandieri*) southward probably into Guatemala.

Use of this name requires explanation. Kellogg in 1932 (U. S. Nat. Mus. Bull. 160:207) pointed out that Cope, in 1886 (Proc. Amer. Philos. Soc. **23**: 517) proposed the name by remarking that the "Mexican specimens referred to in these citations [i.e., in the synonymy for '*Rana halecina* Daudin (Kalm)'] constitute a subspecies, which I call *R. h. austricola*." Kellogg observes that only 3 of the 11 citations mentioned refer to Mexican specimens. He restricts the name to the form represented by a figure published by Brocchi (Miss. Sci. Mex., Batr.: pl. 4, fig. 1, 1881), which the latter author (*op. cit.*, p. 14) states occurs in "Vera Cruz, Mexico. M. Bocourt a recueilli de nombreux échantillons de cette espéce á Salomá et á Tactu (Terres chaudes)." It appears, however, that the localities cited by Brocchi are misprints for Salamá and Tactic, both in Vera Paz (Baja and Alta, respectively), Guatemala. Both localities are indicated on Bocourt's route on the map in livraison 16 (1908) of the Mission Scientifique (opposite p. xii). The "Vera Cruz" is apparently a misinterpretation of "Vera Paz." Accordingly Kellogg's restriction of the type and type locality cannot stand, as the specimen indicated is not actually from Mexico. Therefore the name *R. h. austricola* Cope is hereby restricted to one of the other citations given by Cope (Günther, Cat. Batr. Sal. Brit. Mus., 1859: 15–16), and to the specimen *d* cited therein on p. 16 as follows: "*d*. Halfgrown: not good state. Mexico. From M. Salle's collection. Belly black-spotted." The type locality is furthermore restricted to Veracruz, Veracruz which Sallé undoubtedly visited in his travels in Mexico, as indicated by the apparently Veracruzian origin of many of the species he discovered.

That *R. p. austricola* may occur as far east as Guatemala is indicated by Brocchi's plate (*loc. cit.*), which illustrates an animal very much like the Veracruz specimens. That the species occurs in the Salamá area is verified by Schmidt and Stuart (Publ. Field Mus. Nat. Hist., Zool. Ser., **24**: 241–242. 1941) who "employ the name *pipiens* with reservation, since some geographic division of this form may prove recognizable with further study."

Rana pipiens trilobata Mocquard

A single, small, somewhat emaciated specimen (no. 122056) is from Temisco (south of Cuernavaca), Morelos. It was found in a road-

side ditch April 12, 1943, by W. F. Foshag. It possesses a broader head, apparently shorter snout, and less plicate skin than the specimens of *R. p. austricola*. Kellogg (*op. cit.*: 209) similarly describes the type of *Rana trilobata* (type locality Guadalajara, Jalisco). The race is envisioned as the one occupying the major portion of the Mexican plateau. No earlier name appears to be applicable.

Microhyla usta usta (Cope)

A single specimen (no. 123541) is from San Lorenzo, Veracruz. It contains large numbers of ants in the stomach.

Coleonyx elegans elegans Gray

A single subadult specimen (no. 123498) is from San Lorenzo, Veracruz. The prenasals are in contact.

Anolis sericeus Hallowell

Six adult specimens (nos. 123499–504) are from San Lorenzo, Veracruz. The characteristic central blue dot is present on the gular fan of males, and the supraorbital semicircles are in all separated from each other by a minimum of one row of scales.

Anolis tropidonotus Peters

A single specimen (no. 118637) is from Río de las Playas, on the boundary of the states of Veracruz and Tabasco, taken March 1–8, 1944, by M. W. Stirling. It is an adult female.

Sceloporus aeneus aeneus Wiegmann

One adult female (no. 122052) was collected by W. F. Foshag on a hill by the trout hatchery near the summit of the Toluca highway, not far from Salazar, México. The canthal is single; dorsal scales 39; femoral pores 16–18, the two series in contact medially.

Sceloporus grammicus microlepidotus Wiegmann

A single juvenile specimen (no. 122057) was collected June 1, 1943, by W. F. Foshag, at a locality between Zurumbeneo and Cerro Cárnica, Michoacán. It possesses 78 dorsals from occiput to base of tail.

Lepidophyma flavomaculatum flavomaculatum Duméril

A single specimen (no. 118638) is from Río de las Playas, on the border of the states of Veracruz and Tabasco, collected March 1–8, 1944, by M. W. Stirling. The femoral pores number 17-17, and most of the whorls of the tail (all but 4) are separated dorsally by 4 rows of scales.

Eumeces copei Taylor

One juvenile (no. 122053) was collected by W. F. Foshag on a hill by the trout hatchery near the summit of the Toluca highway, not far from Salazar, México. Pattern and scutellation are typical.

Ameiva undulata amphigramma Smith and Laufe

Three half-grown and juvenile specimens (nos. 123505–7) are from San Lorenzo, Veracruz. One (a male, the smallest) shows very little evidence of the dorsolateral dark stripe, while it is more distinct though variable in intensity (spotted) in the others (females, the largest measuring 68 mm snout to vent). The largest female shows faintly the upper lateral light line, but in the others it is not at all evident. Respectively (as numbered above) the femoral pores are 17–18 ♀, 19–19 ♀, 18–19 ♂; lamellae on 4th toe 26–27, 28–28, 26–28; rows of gulars 5 (one divided), 6 (two divided) and 4 (none divided).

Ficimia publia Cope

Twenty-two specimens have been reported of this species. Two others are available in the present collection, both from the state of Veracruz. Of prime interest is the fact that each of the latter has only 1–1 postoculars and 0–0 internasals.

F. publia is known to range from southern Veracruz to Honduras (including the Yucatán peninsula) on the Atlantic coast, and from Guerrero to western Guatemala on the Pacific. As indicated by Smith and Taylor (Journ. Washington Acad. Sci. **31**: 364. 1941) the specimens available exhibit certain variations in pattern that indicate the probability of a geographic segregation of recognizably different forms. No indication of geographic segregation of variations in scutellation was then apparent. The recent acquisitions from Veracruz indicate, however, that the population in that area is recognizably different in at least two characters of head scales.

It has been observed previously that the number of postoculars varies in *F. publia* from 1 to 2, although most specimens (17 out of 18) have two on one or both sides (2–2, 13; 1–2, 4). The only one recorded with 1–1 postoculars is the single specimen known from the state of Veracruz (Minatitlán). With the present pair, we now have 3 specimens from that state; all have 1–1 postoculars, while all others have 1–2 or 2–2. It is noteworthy that at least 2 of the non-Veracruzian specimens with 1 postocular have reduced the number through obvious fusion of the upper with the supraocular, while in the Veracruz specimens the reduction in number is due apparently to fusion together of the two scales.

Furthermore, all Veracruzian specimens lack the internasals completely. Only one other (from Yucatán) of the 20 known from elsewhere lacks them on both sides; one (Honduras) lacks the scale on one side, and one other (Petén) has it partially fused with the prefrontals on one side. Accordingly the internasals are absent in 100 percent of the known Veracruz specimens, but in only 5 percent of the remainder is it completely absent. Considering the two sides separately, only 10 percent of the individual internasals of non-Veracruzian specimens are either wholly or partially fused with the prefrontal.

These differences between the Veracruz and other populations may be summarized as follows:

Veracruz		*Elsewhere*	
postoculars	1-1 (3 spec.)	postoculars	2-2 (13)
			1-2 (4)
internasals	0-0 (3 spec.)	internasals	0-0 (1)
			0-1 (1)
			1-1 (1)
			1-1 (17)

Since the Veracruz specimens inhabit an area well known to be distinctive faunistically from adjacent areas, it is reasonable to suppose that the largely distinctive characters observed in the 3 specimens available hold with reasonable constancy throughout that area. The maximum geographic range of the race is not apparent. It may be limited to the coastal plain from the Isthmus northwestward, or, as is here considered more probable, may extend eastward to the base of the Yucatán peninsula. No other specimens are known from this entire area.

That Veracruz specimens might well prove to be different from others of *F. publia* was first indicated by Taylor (Proc. Biol. Soc. Washington **49**: 54. 1936) who allocated one individual —the first recorded from the state—with *F. variegata* (which likewise normally lacks the internasals) rather than with *F. publia* (which he regarded as always having internasals). As a tribute to his discernment I suggest the race be called—

Ficimia publia taylori, n. subsp.

Types.—HOLOTYPE: U. S. N. M. no. 123491, an adult male from San Lorenzo, Veracruz, collected in the period from February to April 1946 by Matthew W. Stirling. PARATYPE: U. S. N. M. no. 123492, a young male with the same data as the type. HYPOPARATYPE: The specimen originally described by Taylor (*loc. cit.*) from Minatitlán, Veracruz, at that time in the private collection of John A. Rickards of Mexico City. Present location unknown.

Diagnosis.—Allied to *Ficimia publia publia*, having a reduced number (about 30) of large blotches as wide as the interspaces on the back; differing from that race usually in lacking internasals and having only one postocular on each side.

Description of holotype.—Rostral much longer than wide, 4.0 mm in length (to cutting edge), 2.9 in width (dorsal portion only); frontal exactly as long as rostral; rostrofrontal suture 1.5 mm in width; supralabials and infralabials 7–7; preoculars and postoculars 1–1, the latter normal in size and shape; internasals 0–0; scale rows 17–16; ventrals 147; tail tip missing, the caudals 39+; total length 362 mm, tail 59 mm.

Dorsum medium brown; 30 irregularly light-edged, dark brown blotches on back, 10 on tail; blotches 2 to 3 scale lengths in extent, about as long as interspaces, reaching laterally to the 4th scale row; numerous small, irregular lateral blotches, in 1 to 3 series, alternating and/or coinciding in position with the dorsal blotches; belly unmarked except at extreme ends of ventrals, onto which some lateral spots extend.

Variation.—In the paratype, the rostral measures 2.4 mm in length, 1.9 mm in width; frontal 3.2 mm in length; rostrofrontal suture 0.8 mm in width; ventrals 148; caudals 42; total length 218 mm, tail 38 mm; other characters of scutellation as in the holotype. Dorsal

spots 30, reaching only to 5th scale row; tail spots 11; lateral spots less fused, in about 4 rows, but very irregular.

Remarks.—At present only the character of the postoculars and internasals is known to suffice in distinguishing the races of *F. publia*. Relative proportions of the frontal and rostral do not appear to be consistently different.

Rhadinaea hesperia hesperia Bailey

A single small specimen (no. 122060) was taken by W. F. Foshag June 25, 1945, at Huautla, Morelos. It is a female, with 178 ventrals and 118 caudals. The pattern agrees perfectly with the diagnosis given by Smith (Proc. Biol. Soc. Washington 55: 185. 1942).

Tantilla bocourti bocourti (Günther)

One small male specimen (no. 122058) was taken by W. F. Foshag at Taxco, Guerrero. It measures 147 mm in total length, the tail 24 mm. Tne ventrals number 180, the caudals 49. A faint middorsal dark line is present, as well as rather extensive light marks on top of the head. The secondary temporal is no longer than broad.

Coniophanes imperialis clavatus (Peters)

Two specimens are available (nos. 123493–4) from San Lorenzo, Veracruz. They have a pattern like that of *C. i. copei* (the sides distinctly darker above than below, the middorsal dark stripe narrow and continuous), but the scale counts are those of *C. i. clavatus* (respectively the ventrals 128, 116, the caudals incomplete (♀) and 81 (♂). The specimens resemble those described by Smith (Proc. U. S. Nat. Mus. 93: 405. 1943) which are stated to lack a separate nape spot. The temporal stripe is long and reaches to the end of the temporal scales in one, but fails to do so in another.

Imantodes cenchoa leucomelas (Cope)

One specimen (no. 118639) is from Río de las Playas, on the border of the states of Veracruz and Tabasco, taken March 1–8, 1944, by M. W. Stirling. Ventrals 235, anal divided, caudals 155.

Oxybelis aeneus auratus (Bell)

Two specimens are available, one (no. 122059) from Huautla, Morelos (June 25, 1945; W. F. Foshag), the other (no. 123495) from San Lorenzo, Veracruz. This is apparently the first record of the species from the state of Morelos. The ventrals are 192 and 194, the caudals 183 and 166 respectively. Neither has an extra preocular.

Bothrops atrox asper (Garman)

Two juvenile specimens (nos. 123496–7) are from San Lorenzo, Veracruz. The ventrals are 216 and 222, the caudals 71 and 72, respectively. One of them (629 mm in total length) contained two *Leptodactylus labialis* in nearly perfect condition, and the hind feet of a tree frog, probably *Smilisca b. baudinii*.

PROCEEDINGS OF THE ACADEMY

410TH MEETING OF BOARD OF MANAGERS

The 410th meeting of the Board of Managers, held in the Cosmos Club, October 6, 1947, was called to order at 8:10 P.M. by the President, Dr. WALDO L. SCHMITT. Others present were: N. R. SMITH, F. M. SETZLER, W. N. FENTON, W. W. DIEHL, F. L. MOHLER, J. S. WADE, A. WETMORE, F. C. COE, W. A. DAYTON, C. A. BETTS, F. B. SILSBEE, M. A. MASON, A. O. FOSTER, H. G. DORSEY, C. L. GAZIN, and, by invitation, G. P. WALTON, J. I. HOFFMAN, and E. A. CHAPIN.

The President introduced the following letter from RICHARD C. DARNELL, chairman of a Special Committee of the District of Columbia Council of Engineering and Architectural Societies:

"The District of Columbia Council of Engineering and Architectural Societies, at its last meeting, gave considerable attention to the problem of securing more effective newspaper announcement of the meetings of its affiliated societies. It was the consensus of opinion that the most desirable immediate step would be to publish a calendar of the various societies' meetings for the forthcoming week in the Sunday newspapers.

"A committee was appointed to work out the details of such a calendar and to secure the cooperation of the local newspapers in publishing it. This committee considers that such a calendar, if inaugurated, should, most ideally, list not only the meetings of affiliated societies of the D. C. Council, but should list the meetings of all scientific and technical groups of Metropolitan Washington. It should make announcements also of any special meetings or exhibits of scientific and technical interest which may be separate

from local scientific and technical societies.

"That the interests of all local scientific and technical societies may be more adequately represented in this effort, it is the pleasure of our committee to invite the Washington Academy of Sciences to cooperate. If the Academy concurs in the desirability of such an effort and wishes to join in it, it is suggested that a representative or representatives be designated to work with us."

The President was authorized to appoint a representative to work with the committee from the D. C. Council of Engineering and Architectural Societies on the calendar of societies' meetings and in securing newspaper cooperation in its publication. The President appointed Dr. FRANK THONE to be the Academy representative.

Four persons were elected to resident membership in the Academy and one to nonresident.

The President requested that in view of the purpose for which the meeting was called, namely to consider the matter of publishing an anniversary volume of the "Red Book," that the regular order of business be set aside so that the greater part of the meeting might be directed to a discussion of this undertaking.

He first, however, brought up the matter of a 31 per cent increase in cost of publishing the JOURNAL, which had been brought to his attention by the Senior Editor, Dr. W. N. FENTON. The Board voted to refer the matter of necessary changes in the JOURNAL budget to the Executive Committee for consideration and recommendations.

The President then brought up the question of an anniversary volume of the "Red Book" and discussed the results of a questionnaire he had earlier circulated among the members with respect to including in this volume the photographs of members of the Academy. Considerable discussion followed both for and against. The motion was made that an anniversary volume of the "Red Book" be published, including reproductions of photographs of the Academy members. The cost of such an undertaking was estimated at $3,000. The motion was carried with the understanding that the cost would be kept below $3,000. Further consideration of unexpected charges, such as for proofreading, etc., prompted the Board to vote a leeway of $000 from the $3,000 estimate.

The President was authorized to appoint a committee to compile such a "Red Book." The committee appointed by the President at the 407th meeting to prepare a "White Book," or Academy directory, was ordered by the Board to furnish its compiled directory material to this "Red Book" committee.

The Secretary communicated a request of the Bacteriological Society, received from its Secretary-Treasurer, Dr. C. W. BOHRER, that Dr. HARRY W. SCHOENING, of the Bureau of Animal Industry, replace Dr. CHESTER W. EMMONS as Vice President of the Academy representing the Bacteriological Society for the current year, inasmuch as Dr. Emmons was unable to carry on the duties of this office. The replacement was approved by the Board of Managers.

The meeting adjourned at 9:55 P.M.

411th MEETING OF BOARD OF MANAGERS

The 411th meeting of the Board of Managers, held in the Cosmos Club, October 20,1947, was called to order at 8:05 P.M. by the President, Dr. WALDO L. SCHMITT. Others present were: N. R. SMITH, F. M. SETZLER, W. N. FENTON, H. B. COLLINS, JR., W. W. DIEHL, F. L. MOHLER, J. S. WADE, W. W. RUBEY, L. E. YOCUM, W. A. DAYTON, C. A. BETTS, A. O. FOSTER, C. L. GARNER, H. G. DORSEY, C. L. GAZIN, and, by invitation, J. I. HOFFMAN and E. A. CHAPIN.

The following appointments were announced by the President:

Committee on Academy Awards for 1947: C. E. CHAMBLISS, General Chairman, and,

Subcommittee for the Biological Sciences: C. E. CHAMBLISS, Chairman, H. B. COLLINS, JR., F. L. LEWTON, G. STEINER, S. F. HILDEBRAND, L. E. YOCUM, and F. O. COE.

Subcommittee for the Engineering Sciences: H. L. WHITTEMORE, Chairman, L. V. BERKNER, P. S. SMITH, H. C. DICKINSON, F. M. DEFANDORF, S. H. MCCRORY, and H. C. DORSEY.

Subcommittee for the Physical Sciences: F. G. ROSSINI, Chairman, H. DIAMOND, J. J. FAHEY, K. F. HERZFELD, F. C. KRACEK, M. X. SULLIVAN, and L. D. FELTON.

Committee of Tellers: A. E. JENKINS, Chairman M. L. BOMHARD, and R. FLANNERY.

The following letter from FRANK M. SETZLER, Custodian and Subscription Manager of Publications, was introduced:

"Due to the prospect of my leaving this country soon after January 1, 1948, for an extended field trip, I hereby wish to tender my resignation as

Custodian of Publications and Subscription Manager.

"I am submitting this resignation at this time so as to assist whomever you may appoint, for my unexpired term, in learning the various procedures.

"I would also like to express my gratitude to you and past Boards for the whole-hearted cooperation extended to me."

The President announced the appointment of Dr. H. A. REHDER as Custodian and Subscription Manager of Publications to fill the vacancy created by Mr. Setzler's resignation.

The following minutes of the Executive Committee were read:

"The Executive Committee met in the Cosmos Club at 8:05 P.M. on October 13, 1947. The President, Dr. WALDO L. SCHMIDT, presided. Others present were: H. S. RAPPLEYE, F. L. MOHLER, N. R. SMITH C. L. GAZIN, and by invitation, W. N. FENTON.

"This meeting was called to consider revision of the JOURNAL budget for the year 1947 necessitated by increases in basic charges for printing of the JOURNAL, a matter referred to the Committee by the Board of Managers at its 410th meeting.

"The Senior Editor, Dr. W. N. FENTON, reported that the new contract which the George Banta Publishing Co. submitted would increase the cost of the JOURNAL about 31 per cent, or $1,240 per year. The printer's proposal that the changes become effective for the November issue indicated an increase in cost for the present year of one-sixth of the annual difference, or about $207. The Executive Committee voted favorably to recommend to the Board of Managers that the 1947 budget for the JOURNAL be increased by $225 to cover the increase in its cost of publication.

"The Committee discussed at length the matter of the illustrated 'Red Book,' including its cost to the Academy invested funds, its composition and format. No specific recommendations were made.

"The meeting adjourned at 10:10 P.M."

The Senior Editor, Dr. W. N. FENTON, presented information on certain economies that had been suggested by the printer, such as changing to a bimonthly or quarterly schedule. However, since these matters were under consideration by the Committee appointed to consider the JOURNAL and its improvement, there was no further discussion. The Board of Managers voted favorably to increase the JOURNAL budget $225 to meet the increase in cost of publication for the current year. The Board also authorized Dr. Fenton to sign the new printing contract on behalf of the Academy.

The President announced, in the absence of the Chairman of the Committee on Meetings, that Prof. I. I. RABI, of Columbia University, would speak at the November meeting of the Academy.

The Chairman of the Committee on Monographs, Dr. E. A. CHAPIN, announced that a manuscript entitled "The Parasitic Birds of Africa," by Dr. HERBERT FRIEDMANN, was under consideration and that it held promise of sale to the extent of repaying cost of publication. No specific recommendation was made to the Board of Managers pending the securing of further details as to estimated cost of publication.

The Chairman of the committee appointed to make recommendations for observance of the 50th Anniversary of the Academy, F. M. SETZLER, commented on the advisability of a dinner, brought up in the questionnaire recently circulated by the President. The results of the questionnaire showed a large majority of those responding in favor of such a dinner, but only half were willing to pay as much as $5.

The Secretary reported the death of Prof. W. P. HAY, retired member and former Vice-President of the Academy (1916), on May 26, 1947; and of Dr. RUDOLF W. GLASER, formerly with the Rockefeller Institute for Medical Research, on September 4, 1947.

FRANCOIS E. MATTHES was transferred to the list of retired members effective December 31, 1947.

The meeting adjourned at 9:30 P.M.

C. L. GAZIN, *Secretary.*

Obituaries

WILLIS LINN JEPSON lived to become the foremost systematic botanist of the Western United States. A native of California, where he was born on August 19, 1867, he delighted to think of himself as an argonaut of botany in the West. His love of California grew from his ranch-home days as a lad in the Vaca Valley of Solano County, and he determined from the day that he met Albert Kellogg in the rooms of the California Academy of Sciences on old Market Street in San Francisco that henceforth he would devote his life to California

botany. From his student days at the University of California at Berkeley, where he edited the campus literary magazine, and came to know intimately Prof. E. L. Greene, of the Department of Botany, to his last decade as emeritus professor of botany, he was constantly associated with that University. As an assistant in botany, 1891–94, then as instructor, 1895–98, assistant professor, 1899–1918, and full professor, 1918–1937, Jepson distinguished himself as the titular head of systematic botany. He was selected as one of the leading 100 botanists of the United States by Cattell in his first survey of scientific personnel in 1906. Many honors, both domestic and foreign, came to him, including his election to the Washington Academy of Sciences as a nonresident member in 1915.

Fired by a compelling desire to provide a working handbook of the native plants of California, supported by a fuller monographic account, he bent his efforts continually to that end, and religiously held to his self-set stint of preparing some copy every day of the year toward that work. He believed that it was only in this way that a scientist could realize the completion of the task that he had set himself. His credo was that a scientist carried a high duty to the Commonweal and must bow his personal desires to its good. Jepson intentionally walled out society to his evident detriment, but not, too, without some evident satisfaction. His laboratory was an "inner sanctum" whether it were in the old Hearst Mining Building or the newer Life Sciences Building. Within its locked (and often bolted!) doors he quietly worked away day in and day out, while cheering football crowds passed beneath his windows and students hurried from one college class to another. This man knew intimately nearly every corner of the state. He had crossed the Sierras at every pass, climbed Telescope Peak, breakfasted with men in the Eel River logging camps, queried "desert rats" on how they had survived a waterless trek across the Amargosa, and their philosophy and food habits, and he returned with plant collections from all these journeys. Nor were the collections hurriedly made. On his field trips he was exasperating for his habit of making the fullest painstaking notes to accompany the specimens; these field notes run to nearly sixty compactly written notebooks, all meticulously indexed. It was these data that went into the several books he authored: *Silva of California*, *Flora of western middle California*[1], *Trees of California*, and a *High school Flora for California*—most of the titles in two or more editions—but the best known book is certainly his *Manual of the flowering plants of California*. This was the first handbook of the California flora, describing 4,019 species. His discussion of the endemism areas of California, the revegetation of the chaparral, and even the proper method of preparing a manual, were notable. Less well known is Jepson's larger definitive *Flora of California*, upon the completion of which he was engaged for the last 25 years of his life. This *Flora* amounts to a monograph, with full bibliographic references, citation of collections, and ecological notes made in the field. Here is Jepson the taxonomist at his best. His botanical library is perhaps the finest private collection in the West. His special prize was a copy of the *Botany of the Beechey Voyage* bought in San Francisco in the nineties for $6.50!

Jepson was not without an international view, but in this he fell far behind his faculty colleague, William Albert Setchell, and, indeed, the two may be said to be most strikingly contrasted for their work in this light. As one botanist has so well said, Jepson worked as a master craftsman bent over the precise details of the flora of California. Setchell, the muralist, was engaged on a great diorama picturing the relationships of the world's floras. Yet Jepson was twice selected a delegate to the International Botanical Congress, first at Cambridge, and later at Amsterdam, serving on the important Committee of Nomenclature. Jepson's part as teacher narrowed from early days when he taught the freshman botany classes in the old "Botany Building" to his later years when his time was devoted exclusively to upper division and graduate classes in taxonomy. Students relished the eagerness that he put into his instruction, along with his anecdote and quizzical retort. His historical writings include a considerable series published in Madroño, a periodical which he founded, entitled "Botanical Explorers of California," and several biographies of naturalists prepared

[1] His doctorate thesis (Ph.D., University of California, 1899); the stock of the printed copies of the first edition destroyed in the 1906 San Francisco fire. Jepson considered this his most finished piece of work.

for the Dictionary of American Biography. He was constantly on the lookout for fresh biographical materials and amassed an astounding fund of *memorabilia* of J. G. Lemmon, E. L. Greene, and many others.

In writing of other men's lives Jepson insisted that it was dishonest to remove what he called the "thorns" from the account. Jepson's "thorns" grew mostly from his desire for recognition from the University and the public in general and his ambition to be unrivaled, and partly to some actual injustices meted out to him in his years at the University. These resulted in an almost pathologic isolation and a neurosis practically amounting to a martyr complex. It became increasingly impossible for him to forgive those who had wronged him, the wrong often amounting to a "breach of loyalty." And at times he made excruciating demands on the loyalty of his friends. Plagued by ill health for his last 30 years, his bitterness was deepened by his awareness that he could not possibly survive to finish the *Flora*—his chief goal in life. Too often Jepson absorbed the careful work of his student assistants or other botanists as his own. It was his view that the work of salaried assistants belonged to him and that no responsibility for individual credit remained. His close friends—men and women in chemistry, geology, zoology, history, and finance—inside and outside the University, prized his luncheon invitations for it was then that the wit and rapier of his meristematic mind came to the fore. Happiest in the open fields of California, he companioned democratically with professor and typesetter, bank president and ferryboat stevedore. Jepson died in Berkeley on November 7, 1946. His services to botanical science and to all those who seek to know more about the native flora of California were such that his name can never be dissociated from it and what men shall write about it.

JOSEPH EWAN

HOWARD SHREVE ROBERTS, physicist at the Geophysical Laboratory of the Carnegie Institution of Washington, died at Presbyterian Hospital, New York City, on January 30, 1947, following an operation. He was born in Philadelphia, Pa. on December 12, 1890. He attended the University of Pennsylvania and Drexel Institute and received degrees in electrical engineering from these institutions in 1912 and 1913, respectively. Subsequently, he was employed as a chemist with the Wirt Co. of Philadelphia; and in 1917 he joined the staff of the Geophysical Laboratory, where he remained until his death.

Mr. Roberts made valuable contributions in a variety of fields. His first research at the Geophysical Laboratory was on the stability relations of the oxides of iron and copper. Later he turned his attention to crystal determination by X-ray techniques; and, following that, to calorimetry, particularly the measurements of heats of melting and other transformations in silicates. His ingenuity with electrical devices not only facilitated his own researches but was freely made available to his colleagues. Particularly important in this connection was his development of a simple and effective temperature regulator that is regularly used in the extensive investigations of silicate equilibria at the Geophysical Laboratory. Indeed, in view of the fact that practicable thermostats for high-temperature furnaces were not generally available until relatively recently, it may be doubted whether certain long series of measurements would have been carried out had it not been for the Roberts regulator.

During World War I, Mr. Roberts worked with the group that was charged with the responsibility for quickly developing an adequate supply of optical glass, a material which prior to that time had not been produced in usable quality in this country. In World War II, he took an important part in the investigation of ordnance matters under the supervision of the Office of Scientific Research and Development. Here again his ingenuity and skill in the design and development of apparatus, especially those involving electric circuits, were of very great value.

Mr. Roberts was a member of the American Association for the Advancement of Science, American Chemical Society, the Philosophical Society of Washington, and the Washington Academy of Sciences. He was a tireless worker, a congenial companion with unfailing tolerance and good humor in his dealings with other persons. His untimely death will be mourned by all who knew him.

L. H. ADAMS